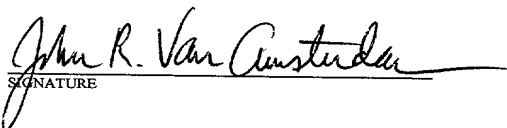

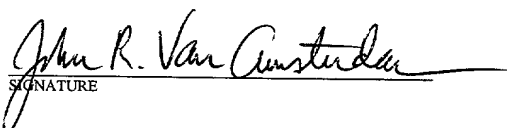



FORM PTO-1390 (REV. 10-2000)		U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER B0192/7031
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371			U.S. APPLICATION NO. (if known, see 37 CFR 1.5) 09/890229
INTERNATIONAL APPLICATION NO. PCT/GB00/00263	INTERNATIONAL FILING DATE 28 January 2000 (28.01.00)	PRIORITY DATE CLAIMED 28 January 1999 (28.01.99)	
TITLE OF INVENTION MANIPULATING ISOPRENOID EXPRESSION			
APPLICANT(S) FOR DO/EO/US BRAMLEY, Peter Michael; HARKER, Mark			
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:			
<ol style="list-style-type: none"> 1. <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 371. 2. <input type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371. 3. <input checked="" type="checkbox"/> This is an express request to promptly begin national examination procedures (35 U.S.C. 371(f)). 4. <input checked="" type="checkbox"/> The US has been elected by the expiration of 19 months from the earliest claimed priority date (PCT Article 31). 5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2)). <ol style="list-style-type: none"> a. <input type="checkbox"/> is transmitted herewith (required only if not transmitted by the International Bureau). b. <input checked="" type="checkbox"/> has been transmitted by the International Bureau. c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US). 6. <input type="checkbox"/> An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)). <ol style="list-style-type: none"> a. <input type="checkbox"/> is transmitted herewith (required only if not transmitted by the International Bureau). b. <input type="checkbox"/> has been transmitted by the International Bureau. 7. <input checked="" type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)). <ol style="list-style-type: none"> a. <input type="checkbox"/> are attached hereto (required only if not transmitted by the International Bureau). b. <input type="checkbox"/> have been communicated by the International Bureau. c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired. d. <input checked="" type="checkbox"/> have not been made and will not be made. 8. <input type="checkbox"/> An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)). 9. <input type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). 10. <input type="checkbox"/> An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(C)(5)). 			
Items 11. To 16. Below concern document(s) or information included:			
<ol style="list-style-type: none"> 11. <input type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98. 12. <input type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included. 13. <input checked="" type="checkbox"/> A FIRST preliminary amendment. 14. <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment. 15. <input type="checkbox"/> A substitute specification. 16. <input type="checkbox"/> A change of power of attorney and/or address letter. 17. <input checked="" type="checkbox"/> A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821-1.825. 18. <input type="checkbox"/> A second copy of the published international application under 35 U.S.C. 154(d)(4). 19. <input type="checkbox"/> A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4). 20. <input checked="" type="checkbox"/> Other items or information: Copy of PCT/RO/101 form Copy of PCT Published Application with Search Report PCT/IB/308 form Copy of International Preliminary Examination Report Statement Pursuant to 37 CFR 1.821(f) w/ diskette and paper copy of sequence listing Express Mail Label No. EL819461955US Date Mailed: July <u>27</u>, 2001 			

U.S. APPLICATION NO. (If known, see 37 CFR 1.57) 097/890229		INTERNATIONAL APPLICATION PCT/GB00/00263		ATTORNEY'S DOCKET NUMBER B0192/7031	
21. <input checked="" type="checkbox"/> The following fees are submitted: BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5)): Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO \$1000.00 International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO \$860.00 International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee paid to USPTO (37 CFR 1.445(a)(2)). paid to USPTO \$710.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) But all claims did not satisfy provisions of PCT Article 33(1)-(4) \$690.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) \$100.00 ENTER APPROPRIATE BASIC FEE AMOUNT = 860.00				CALCULATIONS ^{PTO USE ONLY}	
Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				\$	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total Claims	34-20 =	14	X \$18.00	\$252.00	
Independent Claims	6-3 =	3	X \$80.00	\$240.00	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+\$270.00	\$	
TOTAL OF ABOVE CALCULATIONS				=	\$1352.00
Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.				\$	
SUBTOTAL				=	\$1352.00
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				\$	
TOTAL NATIONAL FEE				=	\$1352.00
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate coversheet (37 CFR 3.28, 3.31). \$40.00 per property				+	\$
TOTAL FEES ENCLOSED				=	\$1352.00
				Amount to be:	\$
				refunded	
				charged	\$
a. <input checked="" type="checkbox"/> A check in the amount of \$ <u>1352.00</u> To cover the above fees is enclosed.					
b. <input type="checkbox"/> Please charge my Deposit Account No. _____ In the amount of \$ _____ To cover the above fees. A duplicate copy of this sheet is enclosed.					
c. <input checked="" type="checkbox"/> The commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 23/2825. A duplicate of this sheet is enclosed.					
d. <input type="checkbox"/> Fees are to be charged to a credit card. WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.					
NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b) must be filed and granted to restore the application to pending status.					
SEND ALL CORRESPONDENCE TO					
WOLF, GREENFIELD & SACKS, P.C. 600 Atlantic Avenue Boston, Massachusetts 02210 Tel: (617) 720-3500			 SIGNATURE John R. Van Amsterdam NAME 40,212 REGISTRATION NO		
CUSTOMER NUMBER			 23628		

U.S. APPLICATION NO. (If known, see 37 CFR 1.57) 097/890229		INTERNATIONAL APPLICATION PCT/GB00/00263		ATTORNEY'S DOCKET NUMBER B0192/7031	
21. <input checked="" type="checkbox"/> The following fees are submitted: BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5)): Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO \$1000.00 International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO \$860.00 International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee paid to USPTO (37 CFR 1.445(a)(2)). paid to USPTO \$710.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) But all claims did not satisfy provisions of PCT Article 33(1)-(4) \$690.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) \$100.00 ENTER APPROPRIATE BASIC FEE AMOUNT = 860.00				CALCULATIONS ^{PTO USE ONLY}	
Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				\$	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total Claims	34-20 =	14	X \$18.00	\$252.00	
Independent Claims	6-3 =	3	X \$80.00	\$240.00	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+\$270.00	\$	
TOTAL OF ABOVE CALCULATIONS				=	\$1352.00
Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.				\$	
SUBTOTAL				=	\$1352.00
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				\$	
TOTAL NATIONAL FEE				=	\$1352.00
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate coversheet (37 CFR 3.28, 3.31). \$40.00 per property				+	\$
TOTAL FEES ENCLOSED				=	\$1352.00
				Amount to be: refunded	\$
				charged	\$
a. <input checked="" type="checkbox"/> A check in the amount of \$ <u>1352.00</u> To cover the above fees is enclosed.					
b. <input type="checkbox"/> Please charge my Deposit Account No. _____ In the amount of \$ _____ To cover the above fees. A duplicate copy of this sheet is enclosed.					
c. <input checked="" type="checkbox"/> The commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 23/2825. A duplicate of this sheet is enclosed.					
d. <input type="checkbox"/> Fees are to be charged to a credit card. WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.					
NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b) must be filed and granted to restore the application to pending status.					
SEND ALL CORRESPONDENCE TO:					
WOLF, GREENFIELD & SACKS, P.C. 600 Atlantic Avenue Boston, Massachusetts 02210 Tel: (617) 720-3500			 SIGNATURE John R. Van Amsterdam NAME 40,212 REGISTRATION NO		
CUSTOMER NUMBER			 23628		

PTO/PT Rec'd 27 NOV 2001

Attorney's Docket No. **B0192/7031**

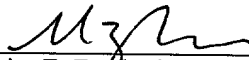
IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants : Bramley et al.
U.S. Serial No. : 09/890,229
International Application No. : PCT/GB00/00263
International Filing Date : 28 January 2000 (28.01.00)
Earliest Priority Date : 28 January 1999 (28.01.99)
Title : MANIPULATING ISOPRENOID EXPRESSION
Examiner : Unknown
Art Unit : 1651

JB

CERTIFICATE OF EXPRESS MAILING UNDER 37 C.F.R. §1.8(a)

The undersigned hereby certifies that this document is being placed in the United States mail via express mail, addressed to Box PCT, U.S. Patent and Trademark Office, P.O. Box 2327, Arlington, VA 22202, on the 27th day of November, 2001.



Monica E. Zornbori

Box PCT
U.S. Patent and Trademark Office
P.O. Box 2327
Arlington, VA 22202


COMMUNICATION

Dear Sir:

The Notification of Missing Requirements which was mailed on September 6, 2001, states that claims 12, 13, and 26 are multiple dependent claims, and as such the multiple dependent claim fee of \$270.00 is required for these claims. However, this seems to be an error. Upon review of the application, Applicants found that claims 12, 13, and 26 were not multiple dependent claims. Therefore, Applicants believe there is no additional claim fee required in this application.

If any fee is determined to be required, please charge the balance to the account of the undersigned, deposit account number 23/2825.

Respectfully submitted,



John R. Van Amsterdam, Reg. No. 40,212
WOLF, GREENFIELD & SACKS, P.C.
600 Atlantic Avenue
Boston, MA 02210-2211
Tel. (617) 720-3500

Attorney's Docket No.: B0192/7031
Date: November 27, 2001
x12/06/01

CRF Errors Corrected by the STIC Systems Branch

Serial Number: 09/870229

CRF Processing Date: 10/05/2004
 Edited by: mt
 Verified by: _____ (STIC sta

- ☐ Changed a file from non-ASCII to ASCII
- ☐ Changed the margins in cases where the sequence text was "wrapped" down to the next line.
- ☐ Edited a format error in the Current Application Data section, specifically: _____
- ☐ Edited the Current Application Data section with the actual current number. The number inputted by the applicant was ☐ the prior application data; or ☐ other **ENTERED**
- ☐ Added the mandatory heading and subheadings for "Current Application Data".
- ☐ Edited the "Number of Sequences" field. The applicant spelled out a number instead of using an integer.
- ☐ Changed the spelling of a mandatory field (the headings or subheadings), specifically: _____
- ☐ Corrected the SEQ ID NO when obviously incorrect. The sequence numbers that were edited were: _____
- ☐ Inserted or corrected a nucleic number at the end of a nucleic line. SEQ ID NO's edited: _____
- ☐ Corrected subheading placement. All responses must be on the same line as each subheading. If the applicant placed a response below the subheading, this was moved to its appropriate place.
- ☐ Inserted colons after headings/subheadings. Headings edited included: _____
- ☐ Deleted extra, invalid, headings used by an applicant, specifically: _____
- ☒ Deleted: ☒ non-ASCII "garbage" at the beginning/end of files; ☐ secretary initials/filename at end of file;
☐ page numbers throughout text; ☐ other invalid text, such as _____
- ☐ Inserted mandatory headings, specifically: _____
- ☐ Corrected an obvious error in the response, specifically: _____
- ☐ Edited identifiers where upper case is used but lower case is required, or vice versa.
- ☐ Corrected an error in the Number of Sequences field, specifically: _____
- ☐ A "Hard Page Break" code was inserted by the applicant. All occurrences had to be deleted.
- ☐ Deleted **ending** stop codon in amino acid sequences and adjusted the "(A)Length:" field accordingly (error due to a PatentIn bug). Sequences corrected: _____
- ☐ Other: _____

*Examiner: The above corrections must be communicated to the applicant in the first Office Action. DO NOT send a copy of this form.

3/1/95

Attorney's Docket No. B0192/7031

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants : Bramley et al.
U.S. Serial No. : 09/890,229
International Application No. : PCT/GB00/00263
International Filing Date : 28 January 2000 (28.01.00)
Earliest Priority Date : 28 January 1999 (28.01.99)
Title : MANIPULATING ISOPRENOID EXPRESSION
Examiner : Unknown
Art Unit : 1651

CERTIFICATE OF EXPRESS MAILING UNDER 37 C.F.R. §1.8(a)

The undersigned hereby certifies that this document is being placed in the United States mail via express mail, addressed to Box PCT, U.S. Patent and Trademark Office, P.O. Box 2327, Arlington, VA 22202, on the 27th day of November, 2001.



Monica E. Zombori

Box PCT
U.S. Patent and Trademark Office
P.O. Box 2327
Arlington, VA 22202

STATEMENT PURSUANT TO 37 CFR 1.821(f) AND 37 CFR 1.825 (a) and (b)

This statement is made pursuant to 37 CFR 1.821 (f), and 37 CFR 1.825 (a) and (b). Applicants submit herewith a substitute copy of the written sequence listing and a computer readable diskette to comply with the sequence requirements.

Applicants' attorney states that the information recorded in computer readable form is identical to the written sequence listing and that neither the computer readable form nor the written sequence listing contain new matter.

Respectfully submitted,



John R. Van Amsterdam, Reg. No. 40,212
WOLF, GREENFIELD & SACKS, P.C.
600 Atlantic Avenue
Boston, MA 02210-2211
Tel. (617) 720-3500

Attorney's Docket No.: B0192/7031
Date: November 27, 2001
x12/06/01

Attorney's Docket No: B0192/7031

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants : Peter BRAMLEY et al.
International Application No. : PCT/GB00/00263
International Filing Date : 28 January 2000 (28.01.00)
Earliest Priority Date : 28 January 1999 (28.01.99)
Title : MANIPULATING ISOPRENOID EXPRESSION

Commissioner for Patents
Box PCT
Washington, DC 20231

PRELIMINARY AMENDMENT

Sir:

Please amend the United States national phase application of the above-identified PCT international application as follows.

In the Specification

Please amend the specification as follows:

Please add the following section as the first section of the specification following the title.

Related Applications

This application is a national stage filing under 35 U.S.C. § 371 of PCT International application PCT/GB00/00263, and filed 28 January 2000, which was published under PCT Article 21(2) in English.

Foreign priority benefits are claimed under 35 U.S.C. § 119(a)-(d) of Great Britain application number GB 9901902.8, filed 28 January 1999.

Please substitute paragraphs of the specification as follows.

Substitute the following paragraph for the paragraph that begins on line 33, page 13 of the specification as filed.

Figure 3: is an illustration of an amino acid sequence alignment of *DXP* synthases used in the present invention, *Synechocystis* sp. 6803 (S.s) (GenBank D90903) (SEQ ID NO: 1), *B. subtilis* (B.s) (GenBank D84432) (SEQ ID NO: 2) and *E. coli* (E.c) (GenBank AF035440) (SEQ ID NO: 3). The consensus line (consen) shows residues conserved in all three sequences (upper case letters) or residues which are identical in two sequences and replaced by an equivalent amino acid in the third sequence (+). The conserved histidine domain putatively involved in proton transfer is over lined and numbered 1. The second over lined domain (2) denotes the consensus thiamin pyrophosphate (TPP)-binding motif.

Substitute the following paragraph for the paragraph that begins on line 35, page 14 of the specification as filed.

Figure 6: is a diagrammatic illustration of vector pVB6_TSEC_LML (SEQ ID NO: 6).

Substitute the following paragraph for the paragraph that begins on line 3, page 15 of the specification as filed.

Figure 7: is a diagrammatic representation of plasmid pVB6_35S_TSEC_LML (SEQ ID NO: 5).

Substitute the following paragraph for the paragraph that begins on line 6, page 15 of the specification as filed.

Figure 8: is an illustration of the amino acid sequence of *E. coli* DXPS (SEQ ID NO: 3).

Substitute the following paragraph for the paragraph that begins on line 9, page 15 of the specification as filed.

Figure 9: is an illustration of the transit peptide used in tomato plants (SEQ ID NO: 4).

Substitute the following paragraph for the paragraph that begins on line 15, page 16 of the specification as filed.

Based on the nucleotide sequence of ORF s111945 from the genome database for *Synechocystis* sp. PCC 6803 [23], primers were designed to clone the putative dxps gene by polymerase chain reaction (PCR). The forward primer 5'-GTCCCAATCCACCATGCACATCAG-3' (SEQ ID NO: 7) overlaps the beginning of the coding sequence. The reverse primer 5'-CCCTCGACAAATGCAAAATGTATC-3' (SEQ ID NO: 8) lies outside the stop codon of the gene. A PCR (25 cycles) using Pfu DNA polymerase (Stratagene) produced a DNA fragment of the expected size (~1.9 kb). Subsequent sequencing of the fragment confirmed the product to be the ORF s111945. The *B. subtilis* dxps gene was also cloned by PCR using primers designed to amplify the gene encoding the product YqiE, identified in the *Bacillus subtilis* genome database [24]. The forward primer 5'-GATCCGCTATGGATCTTTTATC-3' (SEQ ID NO: 9) contains a modified base substitution at the predicted start codon (underlined) for improved expression in *E. coli*. The reverse primer 5'-ATCTAATCGTTCTTTCTTTGAC-3' (SEQ ID NO: 10) lies outside the stop codon of the dxps gene. After PCR (25 cycles) a DNA product of the expected size (~1.9 kb) was obtained, and when sequenced proved to be identical to the gene encoding the product YqiE. The PCR products from both reactions were treated with Taq DNA polymerase (GibcoBRL) at 72°C for 10 min to synthesise blunt ended fragments. The fragments were then cloned into the EcoRV site of the pBluescript vector (Stratagene) using T4 DNA ligase (Fermentas) (Fig. 2).

Substitute the following paragraph for the paragraph that begins on line 32, page 20 of the specification as filed.

The amino acid sequence of the DXPS proteins of *Synechocystis* sp. 6803 (SEQ ID NO: 1) and *B. subtilis* (SEQ ID NO: 2) exhibited significant similarity to each other over their entire length (47% identities) and to *E. coli* DXPS (SEQ ID NO: 3) (*B. subtilis* (44% identities) and *Synechocystis* sp. 6803 (46% identities)) (Fig. 3). All three polypeptides share two conserved domains; one thought to be involved in thiamin binding [30] and a histidine residue postulated to participate in proton transfer [31], both of which are detailed in Fig. 3. The existence of thiamin-

binding domain in each of the polypeptides explains the cofactor requirement of thiamin for DXPS activity [12]. The high degree of polypeptide sequence identity, particularly the distribution of conserved domains, in all three indicates that they all encode DXPS or a closely related gene product.

Substitute the following paragraph for the paragraph that begins on line 34, page 27 of the specification as filed.

Forward: 5'-GCG CCG CTA TTT ACT CGA-3' (SEQ ID NO: 11)

Substitute the following paragraph for the paragraph that begins on line 1, page 28 of the specification as filed.

Reverse: 5'-TTT CTC TGG CGT GCC GCC-3' (SEQ ID NO: 12)

A marked up copy of the specification amendments is attached as Appendix A to facilitate the Examiner's review.

Please substitute the enclosed Sequence Listing for the presently filed Sequence Listing.

In the Claims

Please amend the claims as follows:

5.(amended) A method according to claim 3 wherein said vector comprises one or more nucleic acid sequences encoding a polypeptide(s) capable of producing a desired isoprenoid.

6.(amended) A method according to claim 3 wherein said plant or plant cell is transformed with a further vector comprising one or more nucleic acid sequences encoding a polypeptide(s) capable of producing a desired isoprenoid.

7.(amended) A method according to claim 3 wherein said vector comprising said nucleic acid sequence(s) encoding said DXPS and/or said polypeptide(s) capable of producing said isoprenoid further comprises a nucleic acid sequence of either a tissue specific promoter and/or encoding a plastid transit peptide.

8.(amended) A method according to claim 5 wherein said desired isoprenoid is one conferring a nutritional benefit.

16.(amended) A method according to claim 14, wherein said cell is any of a bacterial, yeast or algal cell.

18.(amended) A method according to claim 14 wherein said organism is a plant.

19.(amended) A method according to claim 14 wherein said cell is any of a bacterial, yeast or algal cell.

20.(amended) A method according to claim 14 wherein said bacterial cell is *E. coli*.

27.(amended) A transgenic cell, tissue or organism according to claim 24, wherein said organism is a plant.

29.(amended) Progeny of the organism according to claim 24 having increased isoprenoid activity.

30.(amended) A transformed plant comprising a transgene capable of expressing DXPS from *E. coli* having the sequence according to SEQ ID NO: 3 and which plant comprises a higher level of isoprenoid than an untransformed plant.

31.(amended) A transformed plant according to claim 30 comprising any of constructs pVB6_TSEC_LML (SEQ ID NO: 6) or pVB6_35S_TSEC-LML (SEQ ID NO: 5).

32.(amended) A transformed plant according to claim 30 wherein said plant is a tomato plant.

A marked up copy of the amended claims is attached as Appendix B to facilitate the Examiner's review.

Remarks

Applicants have amended the specification to provide priority application information and information regarding the publication in English under PCT Article 21(2) of the PCT application of which the above-identified application is a U.S. national stage application. The specification also has been amended to insert sequence identifiers. A substitute Sequence Listing is filed herewith.

Applicants have amended the claims to eliminate certain dependencies and to add sequence identifiers. No new matter has been added.

Respectfully submitted,



John R. Van Amsterdam

Reg. No. 40,212

WOLF, GREENFIELD & SACKS, P.C.

600 Atlantic Avenue

Boston, Massachusetts 02210-2211

Tel: (617) 720-3500

Attorney's Docket No. B0192/7031

Dated: 27 July 2001

Appendix A

Added Section

Related Applications

This application is a national stage filing under 35 U.S.C. § 371 of PCT International application PCT/GB00/00263, and filed 28 January 2000, which was published under PCT Article 21(2) in English.

Foreign priority benefits are claimed under 35 U.S.C. § 119(a)-(d) of Great Britain application number GB 9901902.8, filed 28 January 1999.

Amended Paragraphs of the Specification

Substitute the following paragraph for the paragraph that begins on line 33, page 13 of the specification as filed.

Figure 3: is an illustration of an amino acid sequence alignment of *DXP* synthases used in the present invention, *Synechocystis* sp. 6803 (S.s) (GenBank D90903) (SEQ ID NO: 1), *B. subtilis* (B.s) (GenBank D84432) (SEQ ID NO: 2) and *E. coli* (E.c) (GenBank AF035440) (SEQ ID NO: 3). The consensus line (consen) shows residues conserved in all three sequences (upper case letters) or residues which are identical in two sequences and replaced by an equivalent amino acid in the third sequence (+). The conserved histidine domain putatively involved in proton transfer is over lined and numbered 1. The second over lined domain (2) denotes the consensus thiamin pyrophosphate (TPP)-binding motif.

Substitute the following paragraph for the paragraph that begins on line 35, page 14 of the specification as filed.

Figure 6: is a diagrammatic illustration of vector pVB6_TSEC_LML (SEQ ID NO: 6).

Substitute the following paragraph for the paragraph that begins on line 3, page 15 of the specification as filed.

Figure 7: is a diagrammatic representation of plasmid pVB6_35S_TSEC_LML (SEQ ID NO: 5).

Substitute the following paragraph for the paragraph that begins on line 6, page 15 of the specification as filed.

Figure 8: is an illustration of the amino acid sequence of *E. coli* DXPS (SEQ ID NO: 3).

Substitute the following paragraph for the paragraph that begins on line 9, page 15 of the specification as filed.

Figure 9: is an illustration of the transit peptide used in tomato plants (SEQ ID NO: 4).

Substitute the following paragraph for the paragraph that begins on line 15, page 16 of the specification as filed.

Based on the nucleotide sequence of ORF s111945 from the genome database for *Synechocystis* sp. PCC 6803 [23], primers were designed to clone the putative dxps gene by polymerase chain reaction (PCR). The forward primer 5'-GTCCCAATCCACCATGCACATCAG-3' (SEQ ID NO: 7) overlaps the beginning of the coding sequence. The reverse primer 5'-CCCTCGACAAATGCAAAATGTATC-3' (SEQ ID NO: 8) lies outside the stop codon of the gene. A PCR (25 cycles) using Pfu DNA polymerase (Stratagene) produced a DNA fragment of the expected size (~1.9 kb). Subsequent sequencing of the fragment confirmed the product to be the ORF s111945. The *B. subtilis* dxps gene was also cloned by PCR using primers designed to amplify the gene encoding the product YqiE, identified in the *Bacillus subtilis* genome database [24]. The forward primer 5'-GATCCGCTATGGATCTTTTATC-3' (SEQ ID NO: 9) contains a modified base substitution at the predicted start codon (underlined) for improved expression in *E. coli*. The reverse primer 5'-ATCTAATCGTTCTTTCTTTGAC-3' (SEQ ID NO: 10) lies outside

the stop codon of the dxps gene. After PCR (25 cycles) a DNA product of the expected size (~1.9 kb) was obtained, and when sequenced proved to be identical to the gene encoding the product YqiE. The PCR products from both reactions were treated with Taq DNA polymerase (GibcoBRL) at 72°C for 10 min to synthesise blunt ended fragments. The fragments were then cloned into the EcoRV site of the pBluescript vector (Stratagene) using T4 DNA ligase (Fermentas) (Fig. 2).

Substitute the following paragraph for the paragraph that begins on line 32, page 20 of the specification as filed.

The amino acid sequence of the DXPS proteins of *Synechocystis* sp. 6803 (SEQ ID NO: 1) and *B. subtilis* (SEQ ID NO: 2) exhibited significant similarity to each other over their entire length (47% identities) and to *E. coli* DXPS (SEQ ID NO: 3) (*B. subtilis* (44% identities) and *Synechocystis* sp. 6803 (46% identities)) (Fig. 3). All three polypeptides share two conserved domains; one thought to be involved in thiamin binding [30] and a histidine residue postulated to participate in proton transfer [31], both of which are detailed in Fig. 3. The existence of thiamin-binding domain in each of the polypeptides explains the cofactor requirement of thiamin for DXPS activity [12]. The high degree of polypeptide sequence identity, particularly the distribution of conserved domains, in all three indicates that they all encode DXPS or a closely related gene product.

Substitute the following paragraph for the paragraph that begins on line 34, page 27 of the specification as filed.

Forward: 5'-GCG CCG CTA TTT ACT CGA-3' (SEQ ID NO: 11)

Substitute the following paragraph for the paragraph that begins on line 1, page 28 of the specification as filed.

Reverse: 5'-TTT CTC TGG CGT GCC GCC-3' (SEQ ID NO: 12)

Appendix B

5. A method according to claim 3 [or 4] wherein said vector comprises one or more nucleic acid sequences encoding a polypeptide(s) capable of producing a desired isoprenoid.

6. A method according to claim 3 [or 4] wherein said plant or plant cell is transformed with a further vector comprising one or more nucleic acid sequences encoding a polypeptide(s) capable of producing a desired isoprenoid.

7. A method according to [any of] claim[s] 3 [to 6] wherein said vector comprising said nucleic acid sequence(s) encoding said DXPS and/or said polypeptide(s) capable of producing said isoprenoid further comprises a nucleic acid sequence of either a tissue specific promoter and/or encoding a plastid transit peptide.

8. A method according to [any of] claim[s] 5 [to 7] wherein said desired isoprenoid is one conferring a nutritional benefit.

16. A method according to claim 14 [or 15], wherein said cell is any of a bacterial, yeast or algal cell.

18. A method according to claim 14 [or 15] wherein said organism is a plant.

19. A method according to [any of] claim[s] 14 [to 18] wherein said cell is any of a bacterial, yeast or algal cell.

20. A method according to [any of] claim[s] 14 [to 19] wherein said bacterial cell is *E. coli*.

27. A transgenic cell, tissue or organism according to [any of] claim[s] 24 [to 26], wherein said organism is a plant.

29. Progeny of the organism according to [any of] claim[s] 24 [to 28] having increased isoprenoid activity.
30. A transformed plant comprising a transgene capable of expressing DXPS from *E. coli* having the sequence according to [Figure 8] SEQ ID NO: 3 and which plant comprises a higher level of isoprenoid than an untransformed plant.
31. A transformed plant according to claim 30 comprising any of constructs pVB6_TSEC_LML (SEQ ID NO: 6) or pVB6_35S_TSEC-LML (SEQ ID NO: 5) [illustrated in Figures 6 and 7].
32. A transformed plant according to claim 30 [or 31] wherein said plant is a tomato plant.

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SEQUENCE LISTING

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Harker, Mark

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Val Glu Leu Thr Val Ala Leu Tyr Ser Thr Leu Asp Leu Asp Lys Asp
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Thr Gly Arg Tyr His Asp Phe His Thr Leu Arg Gln Lys Asp Gly Val
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Ala Gly Tyr Leu Lys Arg Ser Glu Ser Arg Phe Asp His Phe Gly Ala
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Gly His Ala Ser Thr Ser Ile Ser Ala Gly Leu Gly Met Ala Leu Ala
115 120 125

Arg Asp Ala Lys Gly Glu Asp Phe Lys Val Val Ser Ile Ile Gly Asp
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Gly Ala Leu Thr Gly Gly Met Ala Leu Glu Ala Ile Asn His Ala Gly
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His Leu Pro His Thr Arg Leu Met Val Ile Leu Asn Asp Asn Glu Met
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Ser Ile Ser Pro Asn Val Gly Ala Ile Ser Arg Tyr Leu Asn Lys Val

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Tyr	Ser	Lys	Val	Phe	Ala	His	Thr	Leu	Thr	Thr	Leu	Ala	Lys	Glu	Asn
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Cys	Leu	Asp	Arg	Ala	Gly	Ile	Val	Gly	Ala	Asp	Gly	Pro	Thr	His	Gln
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Thr	Ser	Leu	Ser	Ala	Ser	Gly	Gly	His	Ile	Gly	Pro	Asn	Leu	Gly	Val
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Val	Glu	Leu	Thr	Val	Ala	Leu	His	Lys	Glu	Phe	Asn	Ser	Pro	Lys	Asp
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Attorney's Docket No: B0192/7031

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants : Peter BRAMLEY et al.
International Application No. : PCT/GB00/00263
International Filing Date : 28 January 2000 (28.01.00)
Earliest Priority Date : 28 January 1999 (28.01.99)
Title : MANIPULATING ISOPRENOID EXPRESSION

Commissioner for Patents
Box PCT
Washington, D.C. 20231

STATEMENT UNDER 37 C.F.R. §1.821(f)

Sir:

This statement is made pursuant to 37 CFR 1.821(f). Applicants enclose herewith an original written copy of the Sequence Listing and a computer readable diskette. Applicants' attorney states that the information recorded in the computer readable form is identical to the written Sequence Listing and that the Sequence Listing contains no new matter.

Respectfully submitted,



John R. Van Amsterdam, Reg No. 40,212
Wolf, Greenfield & Sacks, P.C.
600 Atlantic Avenue
Boston, MA 02210
Telephone (617) 720-3500

Docket No. B0192/7031
Dated: July 27, 2001
xNDD

MANIPULATING ISOPRENOID EXPRESSION

5 The present invention is concerned with manipulating or altering isoprenoid expression in a cell or organism which biosynthesises isopentenyl diphosphate (IPP), which is the universal precursor of all isoprenoids in nature, via a mevalonate independent pathway.

10 Isoprenoids constitute the largest class of natural products occurring in nature, with over 29,000 individual compounds identified to date [1]. Chemically, they are extremely diverse in their structure and complexity. The fundamental biological
15 functions performed by isoprenoids ensure they are essential for the normal growth and developmental processes in all living organisms. These include functioning as eukaryotic membrane stabilisers (sterols), plant hormones (gibberellins and abscisic
20 acid), providing pigments for photosynthesis (carotenoids and phytol side chain of chlorophyll), and as carriers for electron transport (menaquinone, plastoquinone and ubiquinone).

25 All isoprenoids are synthesised via a common metabolic precursor, isopentenyl diphosphate (IPP; C₅). Until recently, the biosynthesis of IPP was generally assumed to proceed exclusively from acetyl-CoA via the classical mevalonate pathway (Fig. 1) [2]. The enzyme
30 3-hydroxy-3-methylglutaryl coenzyme A reductase (HMGR) catalyses the conversion of hydroxymethylglutaryl-CoA to mevalonate, a key reaction of the mevalonate-dependant IPP biosynthetic pathway. Recent
35 studies have demonstrated that mevalonate is not the biosynthetic precursor of IPP in all living organisms

- 2 -

[3,4]. The existence of an alternative, mevalonate-independent pathway for IPP formation was identified initially in several species of eubacteria [4,5] and a green alga [6]. The pathway was subsequently shown to be operational in the plastids of higher plants [7-10]. The first reaction in the non-mevalonate pathway is the transketolase-type condensation reaction of pyruvate and D-glyceraldehyde-3-phosphate to yield 1-deoxy-D-xylulose-5-phosphate (DXP) (Fig. 1). This reaction is catalysed by the enzyme 1-deoxy-D-xylulose-5-phosphate synthase. The second reaction in the pathway is the conversion of DXP to 2-C-methyl-D-erythritol-4-phosphate (MEP). The reactions which convert MEP to IPP have yet to be characterised.

The cloning and characterisation of the DXP synthase (*dxps*) gene has been described for a number of organisms including *Escherichia coli* [11,12] and higher plants [13-15]. The *CLA1* gene product from *Arabidopsis thaliana* associated with chloroplast development [16], for example, has been shown to exhibit *DXPS* activity [11]. Recently, a gene responsible for the reduction of DXP to 2-C-methyl-D-erythritol-4-phosphate, the proposed next step in the non-mevalonate pathway has been cloned from *E. coli* [17].

The present inventors have surprisingly found that the first reaction in the mevalonate-independent IPP biosynthetic pathway is highly influential in controlling the levels of isoprenoids which can be formed in a cell or organism within which the mevalonate independent IPP biosynthetic pathway is present. The enzyme *DXPS* or functional equivalents

- 3 -

thereof, has been identified by the present inventors as a rate-limiting step in isoprenoid biosynthesis and that DXPS activity plays an important role in channelling the carbon resources of the cell into the isoprenoid biosynthetic pathway.

Therefore, according to a first aspect of the present invention there is provided a method of manipulating isoprenoid expression in a cell possessing a mevalonate independent isopentenyl diphosphate synthesising pathway, which method comprises altering the activity of the enzyme 1-deoxy-D-xylulose-5-phosphate synthase (DXPS), or a functional equivalent thereof. Thus, advantageously, the rate-limiting effect conferred by DXPS activity on the IPP biosynthetic pathway can be utilised to manipulate the resultant levels of isoprenoids in a cell by altering the activity or expression of DXPS.

Preferably, the levels of isoprenoids in a cell can be enhanced by increasing the activity or expression of the DXPS. Likewise reduced levels of isoprenoids can be achieved by reducing or inhibiting activity or expression of DXPS in a cell or organism. Increasing the DXPS activity may be achieved by, for example, transforming the cell which may itself be part of a cell line or an organism, with an expression vector comprising a nucleic acid molecule encoding DXPS, which may advantageously be operably linked to a reporter molecule, such as used in the GUS assay which is known in the art. Preferably, the vector comprises any of the vectors designated pBSDXPS or pSYDXPS, illustrated in Figure 2.

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An alternative method for altering expression may comprise utilising a technique known as Enforced Evolution, or DNA Shuffling see Patten et al. Current Opinion in Biotechnology, 1997, Vol. 8, No. 6, pp 724-733, Crameri et al., Nature 1998, Vol. 391, No. 6664, pp 288-291 and Harayama S, Trends in Biotechnology, 1998, Vol. 16, No. 2, pp 76-82. According to this method improvements in enzyme activity can be achieved by reassembling DNA segments into a full length gene by homologous or site specific combination. Before the assembly, the segments are often subjected to random mutagenesis by error prone PCR, random nucleotide insertion, or other such methods. The genes can be expressed in suitable microbial hosts leading to the production of functional polypeptides, such as DXPS.

The nucleic acid encoding the DXPS may be endogenous to the cell or organism into which it will be transformed or, alternatively, may be exogenous. In one embodiment of the invention, the method may also comprise transforming the cell or organism with a vector comprising one or more nucleic acid sequences suitable for producing a desired isoprenoid. This aspect of the invention is particularly advantageous because it allows isoprenoids to be produced in a cell or organism independent of the source of the isoprenoid which may be derived from cells or organisms which do not possess the mevalonate independent IPP biosynthesising pathway. Similarly, enhanced levels of an isoprenoid can be produced in cells or organisms having the mevalonate independent IPP biosynthetic pathway.

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- 5 -

Therefore, in the example where the cell is *E. coli* it is possible to engineer production of an isoprenoid which is exogenous to the *E. coli* bacterium, which isoprenoid may be, for example, any of the carotenoids of plants, such as, lycopene or even an isoprenoid of human origin.

Carotenoids are yellow-orange-red lipid based pigments found in nature. They have been found to be useful in a variety of applications, for example, as supplements, and particularly vitamin supplements, as vegetable oil based food products and food ingredients, as feed additives in animal feeds and as colorants. Phytoene has been found to be useful in treating skin disorders whilst lycopene and α and β carotene consumption have been implicated as having preventative effects against certain kinds of cancers. Therefore, it is a highly advantageous aspect of the invention that increased production of such compounds can be achieved and which compounds can confer considerable health care benefits. Once the desired carotenoid or other isoprenoid has been produced in *E. coli*, or other suitable organism as defined above, it can be isolated using standard biocengineering techniques.

Increases in concentrations of any desired isoprenoid may be achieved, in a cell or alternatively an organism which possesses the IPP biosynthetic mevalonate independent pathway. For example, crops can be engineered using the method of the invention to produce increased levels of an isoprenoid which confers nutritional benefits to humans following consumption of the plant, such as, for example, vitamin E and lycopene.

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Therefore, there is also provided by a further aspect of the invention a cell or organism having a mevalonate independent IPP biosynthetic pathway and which has been transformed or transfected with an expression vector comprising a nucleic acid molecule encoding DXPS or a functional equivalent or bioprecursor thereof. As described above, the vector may also include one or more further nucleic acid sequences suitable for producing a desired isoprenoid, or alternatively the one or more nucleic acid sequences may be included in a separate vector, operably linked to suitable expression control sequences. In a particularly preferred embodiment the cell or organism comprises a plant.

An expression vector according to the invention includes a vector having a nucleic acid sequence operably linked to regulatory sequences, such as promoter regions, that are capable of effecting expression of said DNA fragments. The term "operably linked" refers to a juxtaposition wherein the components described are in a relationship permitting them to function in their intended manner. Such vectors may be transformed into a suitable host cell or organism to produce a desired protein, such as DXPS or an isoprenoid according to the method of the invention. Thus, in a further aspect, the invention provides a process for producing a desired isoprenoid which comprises cultivating a host cell, transformed or transfected with an expression vector as described above under conditions to provide for expression by the vector of DXPS or a functional equivalent thereof or suitable polypeptides for producing a desired isoprenoid and optionally recovering the expressed polypeptides.

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The vectors may be, for example, plasmid, virus or phage vectors provided with an origin of replication, optionally a promoter for the expression of said nucleotide and optionally a regulator of the promoter.

5 The vectors may contain one or more selectable markers, such as, for example, ampicillin resistance.

Regulatory elements required for expression include promoter sequences to bind RNA polymerase and

10 transcription initiation sequences for ribosome binding. For example, a bacterial expression vector may include a promoter such as the lac promoter and for transcription initiation in the Shine-Dalgarno sequence and the start codon AUG. Similarly, a

15 eukaryotic expression vector may include a heterologous or homologous promoter for RNA polymerase II, a downstream polyadenylation signal, the start codon AUG, and a termination codon for detachment of the ribosome. Such vectors may be obtained

20 commercially or assembled from the sequences described by methods well known in the art.

By combining the nucleic acid sequences encoding said DXPS and optionally the one or more sequences suitable

25 for producing an isoprenoid with tissue specific promoters, enhanced isoprenoid levels in specified tissues of plants can be achieved. For example, by utilising a seed specific promoter or other

transcriptional initiation region, elevated levels of

30 carotenoids in seeds may be achieved. The seed can then be harvested and which provides a reservoir for the isoprenoid or carotenoid of interest.

Generally, the nucleic acid molecule encoding said

35 DXPS which is included in the vector used in

accordance with the method of the invention, will be transformed into a plant cell so that the DXPS molecule is directed to the plastids of the plant. Accordingly, where the vector is not inserted directly into the plastid of the plant, the vector will further comprise a nucleic acid sequence operably linked to said DXPS or said one or more isoprenoid producing nucleic acid sequences and which further sequence will encode a transit peptide to direct expression of the DXPS or isoprenoid into the plastid. Native or heterologous transit peptides may be utilised in this embodiment of the invention.

As aforesaid, the mevalonate independent IPP biosynthetic pathway is not present in any higher animals, particularly humans. Therefore, the inhibition of the reaction catalysed by DXPS provides a unique target site to selectively inhibit or alleviate bacterial associated infections by altering the expression level of or inhibiting function or activity of DXPS.

One method of inhibiting or preventing expression of DXPS utilises antisense technology. Antisense technology can be used to control gene expression through helix formation of antisense DNA or RNA, both of which methods are based on polynucleotide binding to DNA or RNA. For example, the 5'-coding region of a native DNA sequence coding for DXPS according to the invention may be used to design an antisense RNA nucleotide of from 10 to 50 base pairs in length. A DNA oligonucleotide is designed to be complementary to a region of the gene involved in transcription (triple-helix - see Lee et al, Nucl. Acids. Res., 6:3073 (1978); Cooney et al., Science, 241:456 (1988);

and Derman et al., Science 251:1360 (1991), in which case expression of the antisense RNA oligonucleotide allows hybridisation to the mRNA *in vivo* and blocks translation of an mRNA molecule into DXPS.

5

Alternatively, compounds can be screened for their ability to inhibit the catalytic activity or expression of DXPS in the mevalonate - independent IPP biosynthetic pathway. According to a further aspect of the invention, therefore, there is also provided a method of identifying a compound which modulates isoprenoid production or expression which method comprises contacting said compound to be tested with a molecule from the mevalonate independent IPP biosynthetic pathway and which molecule undergoes a reaction in the presence of an appropriate reactant catalysed by DXPS, in the presence of DXPS and monitoring the level of product produced when compared to the same reaction in the absence of the compound to be tested. Preferably, the molecules which are reacted are pyruvate and glyceraldehyde-3-phosphate, and which undergo a condensation reaction in the presence of DXPS, to yield 1-deoxy-D-xylulose-5-phosphate (DXP) as illustrated in Figure 1.

25

Any compounds identified as preventing expression or activity of the DXPS enzyme according to the invention may advantageously be particularly useful as selective toxicity agents to destroy, for example, bacterial or plant cells which possess the mevalonate independent IPP biosynthetic pathway. These compounds therefore can be particularly useful as medicaments or herbicides, or alternatively in the preparation of a medicament for treating bacterial associated diseases.

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- 10 -

A further aspect of the invention therefore also comprises a pharmaceutical composition comprising a compound identified as an inhibitor of expression or activity of DXPS or a functional equivalent or bioprecursor thereof, together with a pharmaceutically acceptable carrier, diluent or excipient thereof. Also provided by the invention is a herbicidal composition comprising said compound identified as an inhibitor of expression or activity of DXPS function.

10

An even further aspect of the invention comprises a transgenic cell, tissue or organism having a mevalonate independent IPP biosynthetic pathway, which comprises a transgene capable of expressing at least one additional DXPS molecule according to the invention. The transgenic cell, tissue or organism may also comprise a transgene having one or more nucleic acid sequences capable of producing a desired isoprenoid. Preferably, the transgenic cell comprises a plant and even more preferably tomato plants.

20

The term "transgene capable of expression" as used herein means a suitable nucleic acid sequence(s) which leads to expression of DXPS or proteins having the same function and/or activity and/or encoding proteins capable of producing a desired isoprenoid. The transgene, may include, for example, isolated genomic nucleic acid or synthetic nucleic acid, including DNA integrated into the genome. Preferably, the transgene comprises the nucleic acid sequence(s) encoding the DXPS enzyme or said isoprenoid as described herein, or a functional fragment of said nucleic acid. A functional fragment of said nucleic acid should be taken to mean a fragment of the gene comprising said nucleic acid(s) coding for the DXPS enzyme or said

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isoprenoid or a functional equivalent, derivative or a non-functional derivative such as a dominant negative mutant, or bioprecursor thereof. For example, it would be readily apparent to persons skilled in the art that nucleotide substitutions or deletions may be made using routine techniques, which do not affect the protein sequence and subsequent functioning of the DXPS enzyme and/or isoprenoid producing proteins encoded by said nucleic acid(s).

10

The DXPS enzyme expressed or the isoprenoid produced by said transgenic cell, tissue or organism or a functional equivalent or bioprecursor of said protein also forms part of the present invention.

15

The recombinant DNA molecules or vectors of the invention can be introduced into a plant cell in a number of recognised ways in the art and it will be appreciated that the choice of method used might depend on the type of plant, i.e. monocot or dicot, targeted for transformation. Suitable methods of transforming plant cells include microinjection (Crossway et al. (1986) BioTechniques 4:320-334), electroporation (Riggs et al. (1986) Proc. Natl. Acad. Sci. USA 83:5602-5606, Agrobacterium mediated transformation (Hinchee et al. (1988) Biotechnology 6:915-921) and ballistic particle acceleration (see, for example, Sanford et al., U.S. Patent 4,945,050; and McCabe et al. (1988) Biotechnology 6:923-926).

30

Alternatively, in the case of an organism, such as a plant, a plastid can be transformed directly. Stable transformation of chloroplasts has been reported in higher plants, see, for example, SVAB et al. (1990) Proc. Natl. Acad. Sci. USA 87:8526-8530; SVAB & Maliga

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(1993) Proc. Natl. Acad. Sci. USA 90:913-917; Staub & Maliga (1993) Embo J. 12:601-606. The method relies on particle gun delivery of DNA containing a selectable marker and targeting of the DNA to the plastid genome through homologous recombination. In such methods, plastid gene expression can be accomplished by use of a plastid gene promoter or by trans-activation of a silent plastid-borne transgene positioned for expression from a selective promoter sequence such as that recognised by T7 RNA polymerase. The silent plastid gene is activated by expression of the specific RNA polymerase from a nuclear expression construct and targeting of the polymerase to the plastid by use of a transit peptide. Tissue-specific expression may be obtained in such a method by use of a nuclear-encoded and plastid-directed specific RNA polymerase expressed from a suitable plant tissue specific promoter. Such a system has been reported in McBride et al. (1994) Proc. Natl. Acad. Sci., USA 91:7301-7305.

The cells which have been transformed may be grown into plants in accordance with conventional methods known in the art. See, for example, McCormick et al., Plant Cell Reports (1986), 5:81-84. These plants may then be grown, and either pollinated with the same transformed strain or different strains, and the resulting hybrid having the desired phenotypic characteristic identified. Two or more generations may be grown to ensure that the subject phenotypic characteristic is stably maintained and inherited and then seeds harvested to ensure the desired phenotype or other property has been achieved.

A host cell of any plant variety may be employed.

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Plant species which provide seeds of interest are particularly useful. For the most part, plants will be chosen where the seed is produced in high amounts, a seed-specific product of interest is involved, or the seed or a seed part is edible. Seeds of interest include the oil seeds, such as oilseed Brassica seeds, cotton seeds, soybean, safflower, sunflower, coconut, palm, and the like; grain seeds, e.g. wheat, barley, oats amaranth, flax, rye, triticale, rice, corn, etc.; other edible seeds or seeds with edible parts including pumpkin, squash, sesame, poppy, grape, mung beans, peanut peas, beans, radish, alfalfa, cocoa, coffee, tree nuts such as walnuts, almonds, pecans, chick-peas etc.

The invention may be more clearly understood from the following exemplary embodiment described with reference to the accompanying drawings wherein:

Figure 1: is an illustration of the mevalonate-dependant (A) and independent (B) pathways for IPP biosynthesis. Proposed reactions for the biosynthesis of 1-deoxy-D-xylulose-5-phosphate from pyruvate and glyceraldehyde-3-phosphate, catalysed by DXPS is as shown inside the box.

Figure 2: is an illustration of structure of plasmids pBSDXPS and pSYDXPS.

Figure 3: is an illustration of an amino acid sequence alignment of DXP synthases used in the present invention,

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5 Synechocystis sp. 6803 (S.s) (GenBank
D90903), B. subtilis (B.s) (GenBank
D84432) and E. coli (E.c) (GenBank
AF035440). The consensus line (consen)
shows residues conserved in all three
sequences (upper case letters) or
residues which are identical in two
sequences and replaced by an equivalent
amino acid in the third sequence (+).
10 The conserved histidine domain
putatively involved in proton transfer
is over lined and numbered 1. The
second over lined domain (2) denotes
the consensus thiamin pyrophosphate
15 (TPP)-binding motif.

Figure 4: is a graphic representation of lycopene
accumulation in recombinant E. coli
cultures expressing vector only (\square),
20 B. subtilis DXPS (\bullet) and Synechocystis
sp. 6803 DXPS (Δ). (Data are means \pm
S.E.M. from three independent
determinations.)

25 Figure 5: is an illustration of lycopene (open
columns) and UQ-8 (shaded columns)
content of E. coli control cultures
(vector only) or expressing exogenous
B. subtilis dxps (B. subtilis),
30 Synechocystis sp. 6803 dxps (sp. 6803)
or A. thaliana hmgr1 (HMGR1) genes.
(Data are means (S.E.M. from three
independent determinations.)

35 Figure 6: is a diagrammatic illustration of

- 15 -

vector pVB6_TSEC_LML.

Figure 7: is a diagrammatic representation of
plasmid pVB6_35S_TSEC-LML.

5

Figure 8: is an illustration of the amino acid
sequence of *E.coli* DXPS.

10

Figure 9: is an illustration of the transit
peptide used in tomato plants.

EXAMPLE 1

15

Materials and methods

Bacterial strains, plasmids, and culture conditions.

20

E. coli strain XL1-Blue (Stratagene) was used for gene
cloning and expression of plasmids. *E. coli* was grown
in Luria Broth media [18] at 37°C on a rotary shaker
at 250 rpm (unless otherwise stated). Ampicillin (100
µg/ml), chloramphenicol (50 µg/ml) and 1.0 mM

25

isopropyl-b'-D-thiogalactoside (IPTG) (all purchased
from Sigma) were added as required. Plasmid
pBluescript (Stratagene) was used as a vector for both
cloning and expression studies. *Synechocystis* sp. PCC
6803 was obtained from the Institute Pasteur (Paris)
and grown in BG11 medium [19] supplemented with 0.5%
glucose at 30°C and 2,000 lux. *Bacillus subtilis*
strain PY79 DNA was a kind gift from P. Wakeley (Royal
Holloway, University of London). The construction of
plasmid pACCRT-EIB, which expresses the *E. uredovora*
crtE, *crtB* and *crtI* genes necessary for lycopene

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biosynthesis in *E. coli* cells into which it has been

- 16 -

introduced, has been described previously [20]. The plasmid used for the expression of HMGR1 cloned into pBluescript (pHMGR1) has also been described elsewhere [21].

5

Recombinant DNA techniques

All recombinant DNA techniques were performed by standard methods [22] or according to suppliers instructions. Genomic DNA was extracted from all organisms using the Qiagen Genomic-tip 20/G kit.

10

Cloning of dxps genes

15 Based on the nucleotide sequence of ORF sll1945 from the genome database for *Synechocystis* sp. PCC 6803 [23], primers were designed to clone the putative dxps gene by polymerase chain reaction (PCR). The forward primer 5'-GTCCAATCCACCATGCACATCAG-3' overlaps
20 the beginning of the coding sequence. The reverse primer 5'-CCCTCGACAAATGCAAAATGTATC-3' lies outside the stop codon of the gene. A PCR (25 cycles) using Pfu DNA polymerase (Stratagene) produced a DNA fragment of the expected size (~1.9 kb). Subsequent sequencing of
25 the fragment confirmed the product to be the ORF sll1945. The *B. subtilis* dxps gene was also cloned by PCR using primers designed to amplify the gene encoding the product YqiE, identified in the *Bacillus subtilis* genome database [24]. The forward primer
30 5'-GATCCGCTATGGATCTT TTATC-3' contains a modified base substitution at the predicted start codon (underlined) for improved expression in *E. coli*. The reverse primer 5'-ATCTAATCGTTCTTTCTTTGAC-3' lies outside the stop codon of the dxps gene. After PCR (25 cycles) a
35 DNA product of the expected size (~1.9 kb) was

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obtained, and when sequenced proved to be identical to the gene encoding the product YqiE. The PCR products from both reactions were treated with Taq DNA polymerase (GibcoBRL) at 72°C for 10 min to synthesise blunt ended fragments. The fragments were then cloned into the EcoRV site of the pBluescript vector (Stratagene) using T4 DNA ligase (Fermentas) (Fig. 2).

In vitro DXP synthase assay

E. coli XL1-blue cells, transformed with the appropriate plasmid, were grown at 37°C in Luria Broth medium with appropriate antibiotics to an OD_{620 nm} of 0.6, and induced by the addition of 1.0 mM IPTG at 28°C for two hours. Bacteria were harvested by centrifugation (6,000g for 10 min) and washed in buffer A (100 mM Tris-HCl (pH 7.5), 1 mM dithioreitol, 0.3 M sucrose). Cells were resuspended to their original volume in buffer B (100 mM Tris (pH 8.0), 1 mM dithioreitol, 0.1 mM phenylmethanesulphonyl fluoride, 1 µ/ml pepstatin, 1 µg/ml leupeptin, 1 mg/ml lysozyme). The cells were then incubated at 30°C for 15 min with gentle agitation, and then disrupted by brief sonication at 4°C. The supernatant was recovered and the protein concentration determined using the Bradford assay [25].

An aliquot of the supernatant (100 µl) was transferred to an Eppendorf tube along with 100 µl of assay buffer containing 100 mM Tris (pH 8.0), 3 mM ATP, 3 mM Mn²⁺, 3 mM Mg²⁺, 1 mM KF, 1 mM thiamine diphosphate, (0.1%) Tween 60, 0.6 Mm mDL-glyceraldehyde-3-phosphate, 30 µM [2-¹⁴C]pyruvate (0.5 µCi). The mixture was incubated for 2 hours at

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30°C with gentle agitation. The reaction was stopped by heating the mixture at 80°C for 3 min. After centrifugation at 13,000 g for 5 min, the supernatant was transferred to a clean tube and evaporated to dryness. The residue was resuspended in methanol (50 μ l) and loaded onto a TLC plate (silica gel 60). Chromatograms were developed in *n*-propyl alcohol/ethyl acetate/H₂O (6:1:3 v/v/v).

Enzyme assays were performed with extracts of induced cells expressing either *Synechocystis* sp. PCC 6803 or *B. subtilis* DXPS, as opposed to control assays in which cells contained only the pBluescript vector without insert. TLC analysis of assays expressing one of the dxps clones exhibited a major band (R_f 0.14) assumed to be DXP which was not observed in the controls. Quantification of ¹⁴C-labelled DXP was achieved by isolation of the reaction product on TLC. The DXP band was scraped off the plate, eluted from the silica using methanol and quantified by liquid-scintillation counting. Enzymatic dephosphorylation of the assay products resulted in the formation of 1-deoxy-D-xylulose (DX), when analysed on TLC (R_f 0.50). When non-radioactive pyruvate was used in the assay, the DXP (R_f 0.12 stained purple) and DX (R_f 0.47 stained blue) were identified by staining with p-anisaldehyde/sulphuric acid (3:1). The DXP co-chromatographed with authentic, chemically synthesised DXP which stained purple also. The reaction substrates pyruvate (R_f 0.36 stained yellow), DL-glyceraldehyde-3-phosphate (R_f 0.15 stained orange) and D-glyceraldehyde (R_f 0.74 stained orange) were also observable using this TLC system. In reactions where the assay products were dephosphorylated no DXP was observed on TLC only DX.

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Quantification of lycopene and ubiquinone QB-8 in *E. coli*

Bacterial growth was determined from the OD_{620 nm}. Dry
5 cell weight was calculated from known volumes of
culture harvested by centrifugation at 13,000 g for 5
min, washed once with water and recentrifuged. The
cells were lyophilised overnight and the weight of the
dried cell pellet determined. The lycopene content of
10 the cells was determined by harvesting aliquots of *E. coli*
cells by centrifugation at 13,000 g for 5 min and
washing once in water followed by recentrifuging. The
cells were resuspended in acetone (200 μ l) and
incubated at 68°C for 5 min in the dark. The samples
15 were centrifuged again 13,000 g for 10 min and the
acetone supernatant containing the lycopene was placed
in a clean tube. The extract was evaporated to
dryness under a stream of N₂ and stored at -20°C in
the dark. The lycopene content of the extracts was
20 determined by visible light absorption spectra using a
Beckman DU Series 7000 diode array spectrometer.
Spectra were recorded in acetone using an A^{1%}_{1cm} of 3450
[26].

25 UQ-8 was extracted from cells based on the methods of
Yoshida et al. [27]. Cells were collected by
centrifugation, washed once with water and then
lyophilised overnight. The dried pellet was extracted
in *n*-propanol (3 ml) and of *n*-hexane (5 ml) containing
30 15 μ g of UQ-10 as an internal standard, by disruption
of the cells using a pestle and mortar. The solvent
phase and that obtained by the second extraction from
the aqueous phase *n*-hexane (3 ml) were combined and
evaporated to dryness under N₂. The residue was
35 resuspended in ethanol and analysed by reversed phase

- 20 -

HPLC as described previously [28]. Peaks were identified by comparing their elution profiles with standards for UQ-7, UQ-9 and UQ-10. A standard of UQ-8 was not available, and the UQ-8 peak was
5 identified by its elution profile relative to those of the other standards [29].

Cloning of the dxps genes

10 The cloning of dxps and the characterisation of the gene product, DXPS, from *E. coli* has recently been reported by two research groups [11,12]. The gene product was shown to exhibit DXP synthase activity, which is considered as the first reaction of the
15 mevalonate-independent pathway for IPP biosynthesis (Fig. 1) [5]. Based on the *E. coli* dxps nucleotide sequence homologs of the gene were identified in the eubacterial genomes of *B. subtilis* and *Synechocystis* sp. PCC 6803. The open reading frame sll1945 in the
20 *Synechocystis* sp. 6803 genome was cloned by PCR, ligated into the vector pBluescript, and designated pSYDXPS (Fig. 2). The gene extends over 1920 bp and contains an open reading frame encoding a polypeptide of 640 amino acids, with a predicted molecular mass of
25 69 kDa. The dxps homolog in the *B. subtilis* genome was identified as the ORF encoding the product YqiE. It was cloned by PCR, and introduced into pBluescript to generate plasmid pBSDXPS (Fig. 2). The gene extends over 1899 bp and encodes a polypeptide of 633 amino
30 acids with a predicted molecular mass of 70 kDa.

The amino acid sequence of the DXPS proteins of *Synechocystis* sp. 6803 and *B. subtilis* exhibited significant similarity to each other over their entire
35 length (47% identities) and to the *E. coli* DXPS (B.

- 21 -

subtilis (44 % identities) and *Synechocystis* sp. 6803 (46 % identities)) (Fig. 3). All three polypeptides share two conserved domains; one thought to be involved in thiamin binding [30] and a histidine residue postulated to participate in proton transfer [31], both of which are detailed in Fig. 3. The existence of a thiamin-binding domain in each of the polypeptides explains the cofactor requirement of thiamin for DXPS activity [12]. The high degree of polypeptide sequence identity, particularly the distribution of conserved domains, in all three indicates that they all encode DXPS or a closely related gene product.

15 Quantification of lycopene and UQ-8 in *E. coli* transformants

Cells of *E. coli* transformed with pACCRT-EIB [20] are pigmented pink due to the accumulation of lycopene. *E. coli* cells engineered to produce lycopene, were transformed with either pBSDXPS, pSYDXPS, pHMGR, or pBluescript to act as a control, to monitor the effect on lycopene biosynthesis when exogenous DXPS was expressed in the cells. The *E. coli* were grown in 50 ml cultures at 30°C with induction by IPTG for 48 hours, by which time they had reached the stationary phase of growth. Figure 4 shows the accumulation of lycopene in the cultures during the 48 hour culture period. The graph clearly demonstrates that the *E. coli* cultures expressing exogenous dxps accumulated lycopene at a much greater rate than the control culture. The final lycopene content of the recombinant dxps strains was approximately double that of the control (Fig. 5). A similar increase was also obtained in *E. coli* cells engineered to produce the

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this organism.

In vitro enzyme activity

5 The increased levels of carotenoids and UQ-8 in *E.*
coli expressing exogenous DXPS were hypothesised to be
due to increased DXPS enzymatic activity in the cells.
This was confirmed by preparing cell homogenates from
10 recombinant *E. coli* strains after induction with IPTG.
Reaction products were measured over a two hour
period, separated by TLC and quantified by
liquid-scintillation counting. The major product
obtained from the reaction co-chromatographed with
chemically-synthesised DXP. This confirms DXP as the
15 major reaction product in the assay. The putative
DXPS function of *B. subtilis* ORF encoding the product
YqiE and *Synechocystis* sp. 6803 ORF sll1945 has been
established by these results. Table 1 shows the
specific activity of DXPS in the recombinant *E. coli*
20 strains. The results show that DXPS activity was
increased in *E. coli* expressing endogenous dxps genes.
This increase was greatest in homogenates containing
the *B. subtilis* DXPS, where a 2.0 fold increase was
observed compared to the controls. Homogenates
25 containing the *Synechocystis* sp. 6803 DXPS exhibited a
1.8 fold increase compared to control reactions.
Therefore, increased DXPS activity in *E. coli*
appears to be responsible for the increased levels of
carotenoids and UQ-8 observed in the transgenic
30 strains. The relative increases in carotenoid levels
between *E. coli* cultures expressing plasmids pSYNDXSP
and pBSDXPS closely resemble the increases observed in
the *in vitro* studies. This suggests that there is a
direct relationship between DXPS activity and the
35 carotenoid content of the cells. This is not the case

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colourless carotenoid phytoene (data not shown). Alterations in the endogenous levels of isoprenoids were determined by measuring the ubiquinone content of the cells. In *E. coli*, the major quinones encountered are ubiquinone (UQ-8) and menaquinone (MK-8) [32]. Ubiquinone is a major component of the aerobic respiratory chain. It is estimated that there are approximately 50 molecules of ubiquinone for each of the oxidation complexes in *E. coli* [33]. By measuring an end product which is produced in relatively large quantities, it was conjectured that alterations in the rates of biosynthesis could be readily detected. The UQ-8 content of the recombinant dxps strains was 1.5 times greater than the controls (Fig. 5). Lycopene and UQ-8 levels were measured in *E. coli* transformed with hmgr1 from *A. thaliana*, to monitor if this caused any alterations in the isoprenoid content of the cells. Expression of the *A. thaliana* hmgr1 cDNA had no effect of the levels of lycopene nor UQ-8 in the cells (Fig. 5).

The results show that increased expression of DXPS leads to increased lycopene and UQ-8 levels in the recombinant *E. coli* cells. This indicates that increasing the rate of DXP synthesis, the initial reaction in the mevalonate-independent pathway for IPP biosynthesis, elevates isoprenoid production. In contrast, expression of hmgr1 had no effect on isoprenoid biosynthesis, suggesting that mevalonate dependent IPP biosynthesis has little or no role in IPP synthesis in *E. coli*. Similarity searches of the *E. coli* genome data base for proteins of the mevalonate-dependent IPP biosynthesis pathway failed to identify any possible homologs in the genome suggesting that this pathway is probably absent in

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for UQ-8 where increases in the levels of UQ-8 are more restricted, which could be due to a rate-limiting reaction later in the UQ-8 biosynthesis pathway [34]. The results support the hypothesis that increased DXPS activity in *E. coli* results in increased levels of carotenoids and UQ-8. These data suggest that isoprenoid levels in *E. coli* can be increased by enhancing DXPS activity.

10 Transformation Protocols in Tomato Plants

Triparental mating

Liquid LB medium (5ml) containing rifampicin (100µg/ml) was inoculated with a single *Agrobacterium tumefaciens* colony picked from an LB/rif plate. It was then incubated in a 27°C shaking incubator (225-250rpm) for 48 hours in the dark. Single colonies of Helper strain *E. coli* HB101/pRK2013 (kanamycin resistant) and the donor were also picked and grown up overnight at 37°C in LB liquid medium with appropriate antibiotics. Following the incubation period each bacterial culture was centrifuged at 10,000rpm for 2 minutes. The supernatants were discarded and the pellets resuspended in LB liquid medium. Aliquots of each strain (100µl each) were then mixed and spread with a sterile spreader onto an LB plate with no selection. The plate was inverted and incubated overnight at 27°C in the dark. A loopful of the overnight mating mix was then streaked onto a LB plate containing selective antibiotics (rifampicin, 100µg/ml and kanamycin 50µg/ml). The plate was inverted and incubated for 48-72 hours at 27°C in the dark. Single colonies could then be selected for use in transformation of tomato explants.

- 25 -

Seed sterilisation

5 Ailsa craig variety of tomato seeds were placed into a sterile 50ml Falcon tube. The seeds were washed with 70% ethanol for 30 seconds and the ethanol removed. 1% Virkon was then added and the tube incubated with shaking at 27°C for 20-30 minutes. 1% Virkon was then added and the tube incubated with shaking at 27°C for 20-30 minutes. The seeds were then washed with sterile dH₂O (~500ml) through a sterile sieve.

Seed sowing

15 MS3S medium (125ml) was poured per sterile double Magenta pot (Sigma) and allowed to set.

Five sterile seeds were then sown in each pot and incubated for 5 weeks in a control temperature room (27°C) under 5 cool white light tubes with 16 hours photoperiod and 70% relative humidity.

Explant preparation

25 Plates were prepared for explant preparation by the addition of MS3C5ZR medium to petri dishes (25 plates per litre of medium). A sterile 8.5cm filter disc was then placed onto each plate. Plates were wrapped in cling film and stored at room temperature. Explants were taken under aseptic conditions for 5 week old seedlings. 1-1.5cm sections from above cotyledons were cut and all leaves, roots and leaf nodes were removed. The explants were placed on a filter disc on pre-incubation medium (10 per plate as prepared in step 1. The plates were then sealed and stored at 35 26°C with low light intensity.

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A. tumefaciens culture preparation

Several *A. tumefaciens* colonies from triparental mating containing either pVB6_TSEC-LML or
5 pVB6_35S_TSEC-LML were picked and used to inoculate LB liquid medium (10mls) containing kanamycin (50µg/ml). The culture was incubated in a shaking incubator (225-250rpm) for 24 hours at 27°C. The overnight culture (10mls) was added to LB liquid medium (50mls)
10 containing kanamycin (50µg/ml). This second culture was then incubated for 24 hours at 27°C in a shaking incubator (225-250rpm).

The *A. tumefaciens* culture (40mls) was then briefly
15 centrifuged in a bench-top centrifuge (up to 3,000rpm) to remove clumps of growth. The supernatant was then carefully collected into a sterile 50ml Falcon tube. The supernatant was spun at 3,000rpm in a bench-top centrifuge for 10 minutes and the supernatant
20 discarded. The pellet was resuspended in MS3S (30mls) by vortexing. The culture was diluted to 1/10th with MS3S and the optical density (OD) at 550nm measured with MS3S as a blank. The OD was adjusted to 0.1 with MS3S 20-25mls of culture was prepared for every 50
25 explants transformed.

Transformation of explants

50 explants were prepared as above (5 plates) and were
30 transferred into petri dishes and 25ml of *A. tumefaciens* solution per petri dish poured over them. They were then incubated at room temperature for 10 minutes before being transferred to petri dishes containing a double layer of sterile filter paper.
35 The explants were then transferred to plates

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containing MS3SC5ZR medium (10 per plate). The plates were sealed and then incubated in a control temperature room (27°C) for 48 hours.

5 Selection

The explants were transferred to selection media MS3C5RCK (10 explants per plate) and sealed before returning to the control temperature room for 2 weeks.

10

Subculture of explants

Following selection explants were subcultured every 2 weeks on MS3C5ZRCK medium. When shoots developed they were carefully excised and transferred to Phytatrays (Sigma) containing MS3C5CK. DNA samples for PCR analysis were collected when shoots were sufficiently developed. Once the shoots rooted they were transferred to the glasshouse where initially they were placed in vermiculite with 1g/L Osmocote slow release fertiliser and then once roots were established they were transferred to soil.

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Constructs for transformation

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pVB6_35S-TSEC-LML and pVB6-TSEC-LML are shown in diagrammatic form in Figures 7 and 6 respectively.

Analysis of transformants

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1. All transformation were tested for the transgene, using PCR with *E.coli* Dxps-specific primers:

Forward: 5'-GCG CCG CTA TTT ACT CGA-3'

35

Reverse: 5'TTT CTC TGG CGT GCC GCC-3'

2. Those that were PCR positive were tested by Southern blot analysis for the number of inserts, using the nptII probe.
3. Single insert transformation were then analysed for Dxps expression using RT-PCR, and the primers described in 1, above.
4. Expressing lines were tested for DXPS protein levels using Western blots with an antibody specific for the *E.coli* protein. A band ca. 69 kDa was found, showing both expression of transgene and cleavage of the transit peptide from the mature protein.
5. Seed was collected from all single insert lines for sowing.
6. T1 progeny were cultivated for pigment analysis and inheritance of phenotype.

Isoprenoids constitute a large group of compounds many of which are of high economic value. The condensation of (hydroxy)thiamin, derived from the decarboxylation of pyruvate, with glyceraldehyde-3-phosphate to yield 1-deoxy-D- xylulose-5-phosphate, is considered to be the first reaction in the mevalonate-independent pathway for IPP and ultimately isoprenoid biosynthesis. The data presented show that increasing the rate of DXP synthesis in *E. coli* results in increased isoprenoid biosynthesis. This finding can therefore be utilised to optimise the industrial production of isoprenoids from bacteria. The

manipulation of enzyme activities important in the biosynthesis of specific isoprenoids in concert with DXPS may be employed to bioengineer the production of specific, high value isoprenoids in *E. coli* or another suitable cell or organism such as in plants where increased isoprenoid production could be used for improving crop flavour, fragrance and colour. Alternatively, crops could be engineered to produce increased concentrations of isoprenoids with pharmaceutical and/or nutritional properties.

TABLE 1. DXP synthase activity in *E. coli* homogenates

	Specific activity nmol/min/mg protein	Fold increase in activity
Control	5.8 \pm 0.07	1.0
<i>B. subtilis</i>	11.5 \pm 0.58	2.0
<i>Syn. sp. 6803</i>	10.4 \pm 0.24	1.8

References

- 5 [1] Dictionary of Natural Products on CD-ROM (v. 5.1). (1996) Chapman and Hall.
- [2] McCaskill, D. and Croteau, R. (1998) TIBTECH, 16, 349-355.
- 10 [3] Horbach, S., Sahm, H. and Welle, R. (1993) FEMS Microbiol. Lett. 111: 135-140.
- [4] Rohmer, M., Knani, M., Simonin, P., Sutter, B. and Sham, H. (1993) Biochem. J. 295, 517-524.
- 15 [5] Rohmer, M., Seeman, M., Horbach, S., Bringer-Meyer, S., Sahm, H. (1996) J. Am. Chem. Soc. 118, 2564-2566.
- 20 [6] Schwender, J., Seeman, M., Lichtenthaler, H. K. and Rohmer, M. (1996) Biochem. J. 316, 73-80.
- [7] Eisenreich, W., Menhard, B., Hylands, P. J., Zenk, M. H., Bacher, A. (1996) Proc. Natl. Acad. Sci. USA 93, 6431-6436.
- 25 [8] Lichtenthaler, H. K., Schwender, J., Disch, A. and Rohmer, M. (1997) FEBS Lett. 400, 271-274.
- [9] Eisenreich, W., Sagner, S., Zenk, M. H. and Bacher, A. (1997) Tetrahedron Lett. 38, 3889-3892.
- 30 [10] Zeidler, J. G., Lichtenthaler, H. K., May, H. U. and Lichtenthaler, F. W. Z. (1997) Naturforsch. 52c, 15-23.
- 35

- 31 -

- [11] Lois, L. M., Campos, N., Putra, S. R., Danielsen, K., Rohmer, M. and Boronat, A. (1998) Proc. Natl. Acad. Sci. USA 95, 2105-2110.
- 5 [12] Sprenger, G. A., Schürken, U., Wiegert, T., Grolle, S., de Graaf, A. A., Taylor, S. V., Begley, T. P., Bringer-Meyer, S. and Sahm, H. (1997) Proc. Natl. Acad. Sci. USA 94, 12857-12862.
- 10 [13] Lange, M. B., Wildung, M. R., McCaskill, D. and Croteau, R. (1998) Proc. Natl. Acad. Sci. USA 95, 2100-2104.
- 15 [14] Bouvier, F., d'Harlingue, A., Suire, C., Backhaus, R. A. and Camara, B. (1998) Plant Physiol. 117, 1423-1431.
- 20 [15] Mochs, C. P., Tan, L., Cunningham, F. X. and Della Penna, D. 9th International Conference on Arabidopsis Research, University of Wisconsin-Madison, USA, June 24-29, 1998 (abstr).
- 25 [16] Mandel, M. A., Feldmann, K. A., Herrera-Estrella, L., Rocha-Sosa and M., Leon, P. (1996) Plant J. 9, 649-658.
- 30 [17] Takahashi, S., Kuzuyama, T., Watanabe, H. and Seto, H. (1998) Proc. Natl. Acad. Sci. USA 95, 9879-9884.
- 35 [18] Miller, J. H. (1972) Experiments in Molecular Genetics, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY.

- [19] Rippka, R., Deruelles, J., Waterbury, J. B.,
Herdman, M. and Stanier, R. Y. (1979) J. Gen.
Microbiol. 111, 1-61.
- 5 [20] Misawa, N., Satomi, Y., Kondo, K., Yokoyama, A.,
Kajiwara, S., Saito, T., Ohtani, T. and Miki, W.
(1995) J. Bacteriol. 177, 6575-6584.
- 10 [21] Caelles, C., Ferrer, A., Balcells, L., Hegardt,
F. G and Boronat, A. (1989) Plant Mol Biol. 13,
627-633.
- 15 [22] Sambrook, J., Fritsch, E. F. and Maniatis, T.
(1989) Molecular cloning : A Laboratory Manual,
2nd Ed., Cold Spring Harbor Laboratory, Cold
Spring Harbor, NY.
- 20 [23] Kaneko, T., Sato, S., Kotani, H., Tanaka, A.,
Asamizu, E., Nakamura, Y., Miyajima, N.,
Hirosawa, M., Sugiura, M., Sasamoto, S., Kimura,
T., Hoshouchi, T., Matsuno, A., Muraki, A.,
Nakazaki, N., Naruo, K., Okumura, S., Shimpo, S.,
Takeuchi, C., Wada, T., Watanabe, A., Yamada, M.,
Yasuda, M. and Tabata, S. (1996) DNA Res. 3,
25 109-136.
- [24] Mizuno, M., Masuda, S., Takemaru, K., Hosono, S.,
Sato, T., Takeuchi, M. and Kobayashi, Y. (1996)
Microbiol. 142, 3103-3111.
- 30 [25] Bradford, J. M. (1976) Anal. Biochem. 72,
248-254.
- 35 [26] Zweig, G., Sherma, J. (1988) CRC Handbook of
Chromatography, Vol. 1., Fat-Soluble Pigments,

- 33 -

CRC Press, Boca Raton, FL.

- 5
- [27] Yoshida, H., Kotani, Y., Ochiai, K., Araki, K.
(1998) J. Gen. Appl. Microbiol. 44, 19-26.
- [28] Van Breeman, R. B. (1995) Anal. Chem. 67,
2004-2009.
- 10
- [29] Collins, M. (1985) Meths. Microbiol. 18, 329-366.
- [30] Hawkins, C. F., Borges, A. and Perham, R. N.
(1989) FEBS Lett. 255, 77-82.
- 15
- [31] Lindqvist, Y., Schneider, G., Ermler, U. and
Sundström, M. (1992) EMBO J. 11, 2373-2379.
- [32] Collins, M. D. and Jones, D. (1981) Microbial.
Rev. 45, 316-354.
- 20
- [33] Wallace, B. J. and Young, I. G. (1977) Biochim.
Biophys. Acta 461, 75-83.
- [34] Hemmi, H., Ochnuma, S., Nagaoka, K. and Nishino,
T. (1998) J. Biochem. 123, 1088-1096.

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Claims

1. A method of manipulating isoprenoid expression in a plant or plant cell having a mevalonate independent isopentyl diphosphate synthesising pathway, which method comprises altering the activity of the enzyme 1-deoxy-D-xylulose-5-phosphate synthase (DXPS), or a functional equivalent thereof.
2. A method according to claim 1 wherein said isoprenoid production is increased by enhancing the activity or expression of said DXPS or lowered by inhibiting the activity or expression of said DXPS enzyme.
3. A method according to claim 2 wherein said enhanced DXPS activity occurs by transformation of said plant or plant cell with a vector comprising a nucleic acid molecule encoding said DXPS operably linked to an expression control sequence and optionally a reporter molecule
4. A method according to claim 3 wherein said DXPS encoded by said nucleic acid sequence is endogenous to said plant or plant cell.
5. A method according to claim 3 or 4 wherein said vector comprises one or more nucleic acid sequences encoding a polypeptide(s) capable of producing a desired isoprenoid.
6. A method according to claim 3 or 4 wherein said plant or plant cell is transformed with a further vector comprising one or more nucleic acid sequences encoding a polypeptide(s) capable of producing a

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desired isoprenoid.

7. A method according to any of claims 3 to 6 wherein said vector comprising said nucleic acid sequence(s) encoding said DXPS and/or said polypeptide(s) capable of producing said isoprenoid further comprises a nucleic acid sequence of either a tissue specific promoter and/or encoding a plastid transit peptide.

8. A method according to any of claims 5 to 7 wherein said desired isoprenoid is one conferring a nutritional benefit.

9. A method according to claim 8 wherein said isoprenoid comprises any of the carotenoids, vitamins E, B1 or B6, chlorophylls, phenylquinones or diterpenes.

10. A plant or plant cell which has a mevalonate independent IPP biosynthetic pathway and which is transformed or transfected with a vector comprising a nucleic acid sequence encoding DXPS or a functional equivalent, derivative or bioprecursor thereof operably linked to an expression control sequence.

11. A plant or plant cell according to claim 10 wherein said vector further comprises a nucleic acid molecule encoding a reporter molecule.

12. A plant or plant cell according to claim 10 or 11 which further comprises a vector comprising one or more nucleic acid sequences encoding one or more polypeptides capable of producing a desired isoprenoid.

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13. A plant or plant cell according to claim 12 wherein said desired isoprenoid comprises any of the carotenoids, vitamin E, B1 or B6, chlorophylls, phenylquinones, or diterpenes.

5

14. A method of manipulating isoprenoid expression in a cell or organism having a mevalonate independent isopentyl diphosphate synthesising pathway, which method comprises altering the activity of the enzyme 3-deoxy-D-xylulose-5-phosphate synthase (DXPS) or a functional equivalent thereof by transforming said cell or organism with a vector comprising a nucleic acid optionally linked to an expression control sequence and operably a reporter molecule, and a further vector comprising one or more nucleic acid sequences encoding a polypeptide(s) capable of producing a desired isoprenoid.

10

15

15. A method according to claim 14, wherein said nucleic acid sequence encoding said DXPS is endogenous to said cell or organism.

20

16. A method according to claim 14 or 15, wherein said cell is any of a bacterial, yeast or algal cell.

25

17. A method according to claim 16, wherein said bacterial cell is *E. coli*.

18. A method according to claim 14 or 15 wherein said organism is a plant.

30

19. A method according to any of claims 14 to 18 wherein said cell is any of a bacterial, yeast or algal cell.

35

20. A method according to any of claims 14 to 19

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wherein said bacterial cell is *E. coli*.

21. A method according to claim 20 wherein said organism is a plant.

5

22. A method of identifying a compound which modulates isoprenoid activity or expression, said method comprising contacting said compound to be tested with a molecule which is a component of the mevalonate independent IPP biosynthetic pathway and which molecule undergoes a reaction catalysed by DXPS activity in the presence of an appropriate reactant, in the presence of DXPS or a functional equivalent thereof and monitoring the yield of a product of the reaction when compared to the same reaction performed in the absence of the compound to be tested.

10

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23. A method according to claim 22 wherein said molecule comprises pyruvate and said appropriate reactant comprises glyceraldehyde-3-phosphate or vice versa.

20

24. A transgenic cell, tissue or organism having a mevalonate independent IPP biosynthetic pathway and increased isoprenoid activity which cell, tissue or organism comprises at least one transgene capable of expressing DXPS or a functional equivalent thereof.

25

25. A transgenic cell, tissue or organism according to claim 24, which comprises at least one additional copy of any of the nucleic acid sequences identified in Figure 3, or the complement thereof.

30

26. A transgenic cell, tissue or organism according to claim 24 or 25, further comprising a transgene capable of expressing one or more polypeptides capable of producing a desired

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isoprenoid, or a functional equivalent.

27. A transgenic cell, tissue or organism
according to any of claims 24 to 26, wherein said
5 organism is a plant.

28. A transgenic cell tissue or organism
according to claim 27, wherein said plant is of the
Lycopersicon spp.

29. Progeny of the organism according to any of
claims 24 to 28 having increased isoprenoid activity.

30. A transformed plant comprising a transgene
15 capable of expressing DXPS from *E.coli* having the
sequence according to Figure 8 and which plant
comprises a higher level of isoprenoid than an
untransformed plant.

31. A transformed plant according to claim 30
20 comprising any of constructs pVB6_TSEC_LML or
pVB6_35S_TSEC-LML illustrated in Figures 6 and 7.

32. A transformed plant according to claim 30 or
25 31 wherein said plant is a tomato plant.

33. A tomato fruit produced by a plant according
to claim 32 and having a higher level of isoprenoid
activity than a wild type fruit.

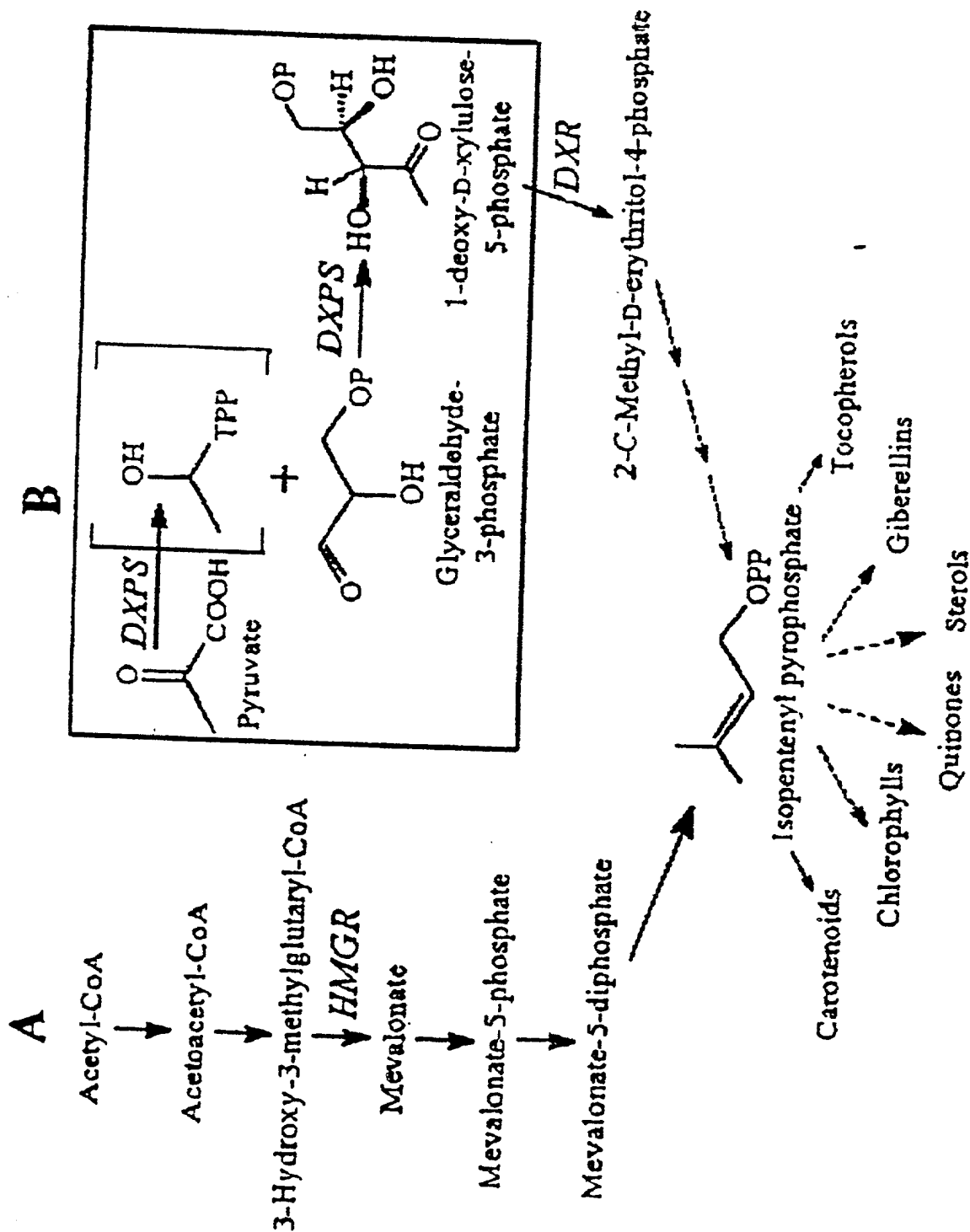
34. A seed produced by a plant according to
claim 32 and having a higher level of isoprenoid
activity than a seed from a wild type plant.

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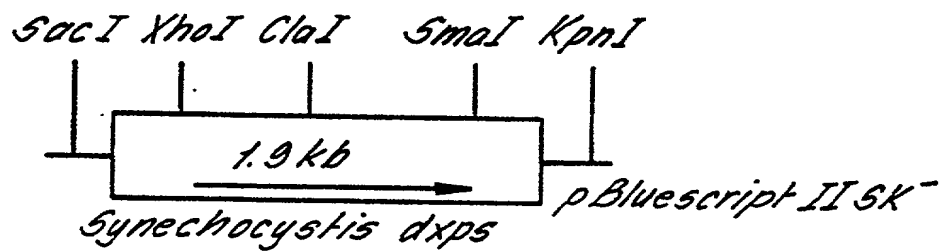
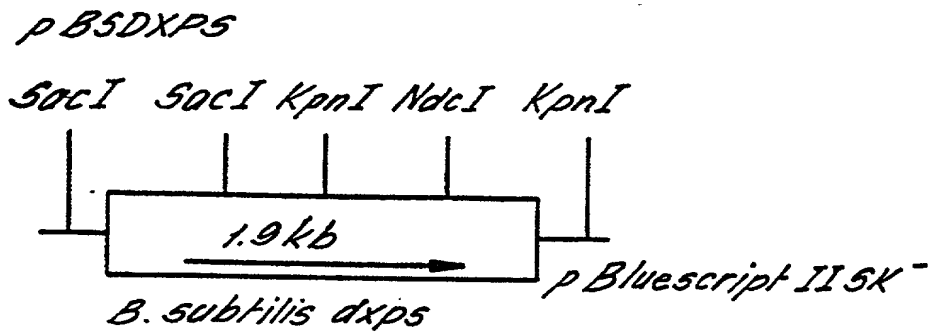
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FIG. 1



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FIG. 2.



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synxxx1 -----MDLLSIQDPSEFLKNMSIDELEKLSDEIROELITSLSASGGHIGPNLGVVELT
bacillus -----MDLLSIQDPSEFLKNMSIDELEKLSDEIROELITSLSASGGHIGPNLGVVELT
Ecolix0 MSFDIAKYPTLALVDSTQELRLLPKESLPKLCDELRRYLDSVSRSSGHEFASGLGTVELT

synxxx1 VALHKEFNSPKDKFLWDVGHQSYVHKLLTGRGKEFATLROYKGLCGEPKRSESEHDVWET
bacillus VALHKEFNSPKDKFLWDVGHQSYVHKLLTGRGKEFATLROYKGLCGEPKRSESEHDVWET
Ecolix0 VALEVVYNTPFQDLIWDVGHQAYPHKILTGRRDKIGTIRQKGGHPEFPWRGESEYDVLSV

synxxx1 GHSSTSLSGAMGMAAARDIKGTDEYIIFIIGDCALTGGMALEALNHIGDEKKDMIVILND
bacillus GHSSTSLSGAMGMAAARDIKGTDEYIIFIIGDCALTGGMALEALNHIGDEKKDMIVILND
Ecolix0 GHSSTSLSAGIGTAVAAEKEGKNRRRTVCVIGDGAITAGMAFEAMNHAGDTRPDMILVILND

synxxx1 NEMSIAPNVGAIHSMGLRLRTAGKYQWVKDELEYLFKKIPAVGGKLAATAERVKDSLKYM
bacillus NEMSIAPNVGAIHSMGLRLRTAGKYQWVKDELEYLFKKIPAVGGKLAATAERVKDSLKYM
Ecolix0 NEMSIAPNVGAILNNHLAGLLSGKLYSSLRGGKKVFSGVPPFIKELKRTTEHTKG-----M

synxxx1 LVSGMFEELGETYLGPVDGHSYHELIENLOYAKKTKGPVLLHVITKKGKGYKPAETDTI
bacillus LVSGMFEELGETYLGPVDGHSYHELIENLOYAKKTKGPVLLHVITKKGKGYKPAETDTI
Ecolix0 VVSGTLEELGFNYIGPVDGHDVGLGLITTLKNMRDLKGPQFLHIMTKKGRGYEPAEKDPFI

synxxx1 GTWHTGTPYKINTGDFVKPAAAPSWSGLVSGTVORMAREDCRIVAITPAMPVGSKLEGF
bacillus GTWHTGTPYKINTGDFVKPAAAPSWSGLVSGTVORMAREDCRIVAITPAMPVGSKLEGF
Ecolix0 -TEHAVPKFDPSSGCLPKSSGGLPSYSKIFGDWLCETAAKDNKLMAITPAMREGSGMVEF

synxxx1 AKEFPDRMFVDVGIAEQHAATMAAAMAMQGMKPFLLAIYSTFLQRAYDQVVDICRONANVF
bacillus AKEFPDRMFVDVGIAEQHAATMAAAMAMQGMKPFLLAIYSTFLQRAYDQVVDICRONANVF
Ecolix0 SRKEPDRMFVDVIAEQHAVTFAAGLALGGYKPIVAIYSTFLQRAYDQVVDHVAIQKLPVL

synxxx1 IGIDRAGLVGADGETHQGVFDIAFMRHIPNMVLMMPKDENEQOHMVHTALS YDEGP I AMR
bacillus IGIDRAGLVGADGETHQGVFDIAFMRHIPNMVLMMPKDENEQOHMVHTALS YDEGP I AMR
Ecolix0 FAIDRAGLVGADGETHQGVFDLSYLRCIPEMVIMTPSDENE CROMLYTG YHYNDGPSAVR

synxxx1 FPRGNGLGVKMDEQLKTIPIGTWEVLRPGNDAVILTFGTTIEMAEAAEELQKEGLSVRV
bacillus FPRGNGLGVKMDEQLKTIPIGTWEVLRPGNDAVILTFGTTIEMAEAAEELQKEGLSVRV
Ecolix0 YPRGNAGVELTP--LEKLPICKGIYKRRGEKLAAILNFGTLMPEAAKVAESLN-----ATL

synxxx1 VNAREIKPIDEKMMKSILKEGLPILTIEEAVLEGCGSSILEFAHDQGEYHTPIDRMGIP
bacillus VNAREIKPIDEKMMKSILKEGLPILTIEEAVLEGCGSSILEFAHDQGEYHTPIDRMGIP
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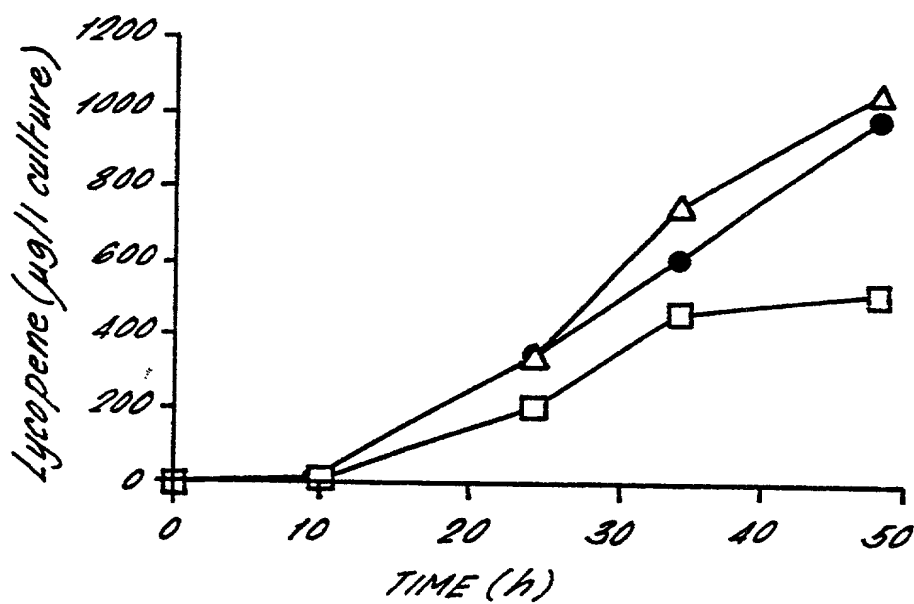
synxxx1 DREIEHGSVTALLEEIGLTKQOVANRIRLLMPKTHKGIGS
bacillus DREIEHGSVTALLEEIGLTKQOVANRIRLLMPKTHKGIGS
Ecolix0 DREIFPQGTQEMRAELGLDAAGMEAKIKAWLA-----

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FIG. 3.

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FIG. 4.



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FIG. 5.

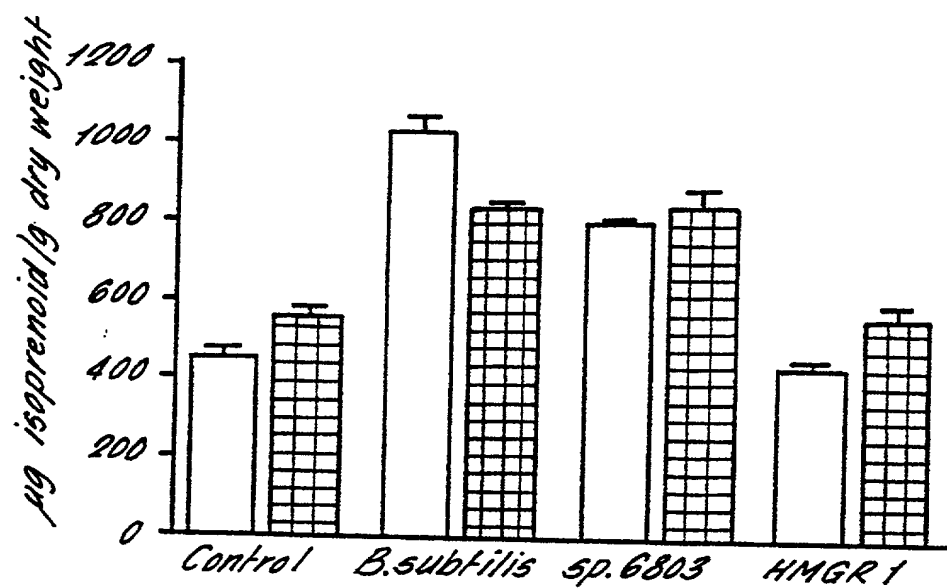
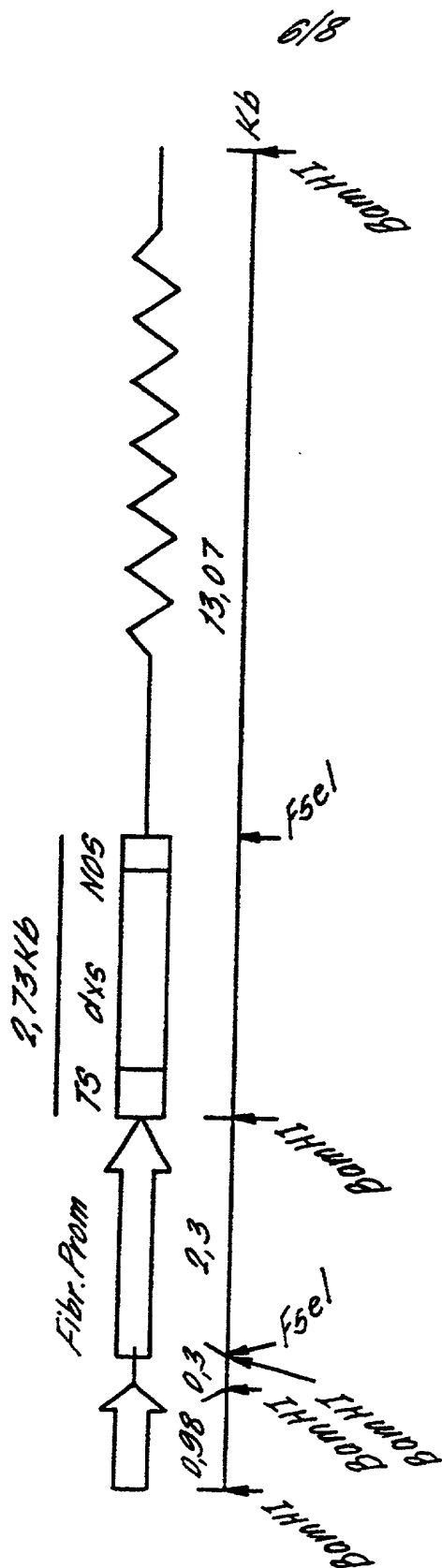
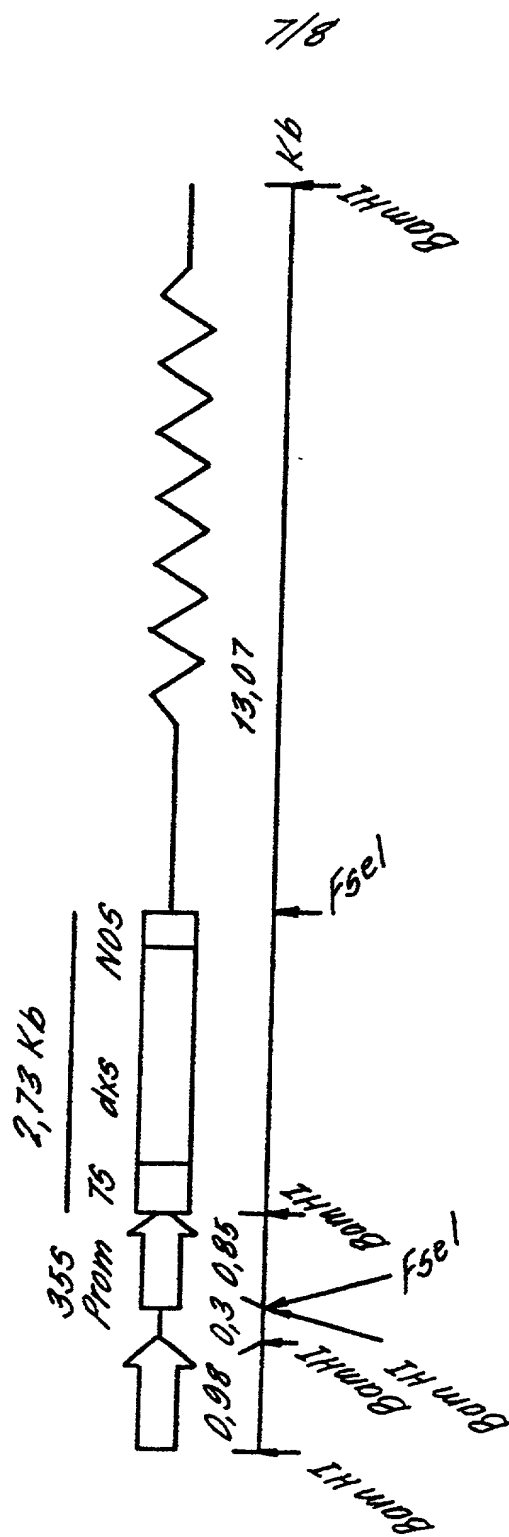


FIG. 6.



Construction name: pVB6-TSEC-LML
 Fibr. Prom: Fibrillin promoter
 TS: Transil sequence
 dxs: deoxyxylulose synthase gene from E. coli
 Date: October 1998

FIG. 7.



Construction name: pVB6_355_TS EC_LML
 355 Prom: 355 promoter
 TS: transit sequence
 dxs: deoxyxylulose synthase gene from E.coli
 Date: October 1998

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FIG. 8.

msfdiakypthalvdstqeirlpkesspkldelrrylldsvsrssghfasglgtveltvalhyvntpfdqliwdvghqa
 yphkiltgrrdkigtirqkgglhpfwrgeseydvlsvghsstsasagigiavaeekgknrrtvcvigdgaitagmfe
 amnhagdirpdmvilndnemsisenvgalnnhlaqlsngklysslreggkkvfsgvppikellkrteehikgmvv
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FIG. 9.

malcayafpgilnrtgvvsdsskatplfsgwihgtldlqflfqhklthevkkrrsvvqaslsesgeyytqrptpildtvny
 pihmknlskelkqladelrsdtifnvsktgghlgsslgvveltvalhyvfnapqdrilwdvghqsyphkiltgrrdkms
 tlrqtdglagfikseseysdcfg

DECLARATION FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am an original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled

MANIPULATING ISOPRENOID EXPRESSION

the specification of which is attached hereto unless the following is checked:

☒ was filed on July 27, 2001, as United States Application No. 09/890,229, bearing attorney docket no. B0192/7031, and was amended on July 27, 2001.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119(a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate, or section 365(a) of any PCT International application designating at least one country other than the United States listed below and have also identified below any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed:

Prior Foreign PCT International Application(s) and any priority claims under 35 U.S.C. §§119 and 365(a),(b):

			Priority Claimed	
<u>9901902.8</u>	<u>Great Britain</u>	<u>January 28, 1999</u>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
(Number)	(Country-if PCT, so indicate)	(DD/MM/YY Filed)	YES	NO
<u> </u>	<u> </u>	<u> </u>	<input type="checkbox"/>	<input type="checkbox"/>
(Number)	(Country-if PCT, so indicate)	(DD/MM/YY Filed)	YES	NO
<u> </u>	<u> </u>	<u> </u>	<input type="checkbox"/>	<input type="checkbox"/>
(Number)	(Country-if PCT, so indicate)	(DD/MM/YY Filed)	YES	NO

I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below:

<u> </u>	<u> </u>
(Application Number)	(filing date)
<u> </u>	<u> </u>
(Application Number)	(filing date)

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s), or §365(c) of any PCT International application(s) designating the United States of America listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

(Application No.)	(filing date)	(status-patented, pending, abandoned)
(Application No.)	(filing date)	(status-patented, pending, abandoned)

PCT International Applications designating the United States:

(PCT Appl. No.)	(U.S. Ser. No.)	(PCT filing date)	(status-patented, pending, abandoned)
-----------------	-----------------	-------------------	---------------------------------------

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

Robert M. Abrahamsen	<u>40,886</u>	Jason M. Honeyman	<u>31,624</u>	Edward J. Russavage	<u>43,069</u>
Constantinos Andrikopoulos	<u>P-48,915</u>	Robert E. Hunt	<u>39,231</u>	Stanley Sacks	<u>19,900</u>
Eric Amundsen	<u>46,518</u>	Ronald J. Kransdorf	<u>20,004</u>	Christopher S. Schultz	<u>37,929</u>
John N. Anastasi	<u>37,765</u>	Peter C. Lando	<u>34,654</u>	Robert A. Skrivaneck, Jr.	<u>41,316</u>
Ian Barzilay	<u>46,540</u>	M. Brad Lawrence	<u>47,210</u>	Alan W. Steele	<u>45,128</u>
Carole Boelitz	<u>P-48,958</u>	Helen C. Lockhart	<u>39,248</u>	Mark Steinberg	<u>40,829</u>
Gary S. Engelson	<u>35,128</u>	Matthew B. Lowrie	<u>38,228</u>	Joseph Teja, Jr.	<u>45,157</u>
Neil P. Ferraro	<u>39,188</u>	William R. McClellan	<u>29,409</u>	Maryanne Trevisan	<u>P-48,207</u>
Thomas G. Field III	<u>45,596</u>	Daniel P. McLoughlin	<u>46,066</u>	John R. Van Amsterdam	<u>40,212</u>
Stephen R. Finch	<u>42,534</u>	James H. Morris	<u>34,681</u>	Robert H. Walat	<u>46,324</u>
Edward R. Gates	<u>31,616</u>	Timothy J. Oyer	<u>36,628</u>	Kristin D. Wheeler	<u>43,583</u>
Richard F. Giunta	<u>36,149</u>	Edward F. Perlman	<u>28,105</u>	Lisa E. Winsor	<u>44,405</u>
Lawrence M. Green	<u>29,384</u>	Elizabeth R. Plumer	<u>36,637</u>	David Wolf	<u>17,528</u>
George L. Greenfield	<u>17,756</u>	Michael J. Pomianek	<u>46,190</u>	Douglas R. Wolf	<u>36,971</u>
James M. Hanifin, Jr.	<u>39,213</u>	Randy J. Pritzker	<u>35,986</u>		
Steven J. Henry	<u>27,900</u>				

Address all telephone calls to John R. Van Amsterdam at telephone no. (617) 720-3500. Address all correspondence to:

John R. Van Amsterdam
c/o Wolf, Greenfield & Sacks, P.C.
Federal Reserve Plaza
600 Atlantic Avenue
Boston, MA 02210-2211

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment,

or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Peter M. Bramley 16/10/07
Inventor's signature _____ Date _____
Full name of first inventor: Peter M. Bramley
Citizenship: Great Britain
Residence: Egham, Surrey, UK GBX
Post Office Address: Royal Holloway University of London, School of Biological Sciences,
Department of Biochemistry, Egham, Surrey TW20 0EX, United
Kingdom

Mark Harker 22/10/07
Inventor's signature _____ Date _____
Full name of second inventor: Mark Harker
Citizenship: Great Britain
Residence: St. Neots, UK GBX
Post Office Address: 10 Langwood Close, Eaton Sorcon, St. Neots PE19 3QN, United
Kingdom

SEQUENCE LISTING

<110> Bramley, Peter Michael
Harker, Mark

<120> Manipulating Isoprenoid Expression

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Val Glu Leu Thr Val Ala Leu Tyr Ser Thr Leu Asp Leu Asp Lys Asp
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Arg Val Ile Trp Asp Val Gly His Gln Ala Tyr Pro His Lys Met Leu
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Patent 6,660,000

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 Ala Glu Gln His Ala Val Thr Leu Ala Ala Gly Met Ala Cys Glu Gly
 370 375 380
 Ile Arg Pro Val Val Ala Ile Tyr Ser Thr Phe Leu Gln Arg Gly Tyr
 385 390 395 400
 Asp Gln Ile Ile His Asp Val Cys Ile Gln Lys Leu Pro Val Phe Phe
 405 410 415
 Cys Leu Asp Arg Ala Gly Ile Val Gly Ala Asp Gly Pro Thr His Gln
 420 425 430
 Gly Met Tyr Asp Ile Ala Tyr Leu Arg Cys Ile Pro Asn Leu Val Leu
 435 440 445
 Met Ala Pro Lys Asp Glu Ala Glu Leu Gln Gln Met Leu Val Thr Gly
 450 455 460
 Val Asn Tyr Thr Gly Gly Ala Ile Ala Met Arg Tyr Pro Arg Gly Asn
 465 470 475 480
 Gly Ile Gly Val Pro Leu Met Glu Glu Gly Trp Glu Pro Leu Glu Ile
 485 490 495

Gly Lys Ala Glu Ile Leu Arg Ser Gly Asp Asp Val Leu Leu Leu Gly
500 505 510

Tyr Gly Ser Met Val Tyr Pro Ala Leu Gln Thr Ala Glu Leu Leu His
515 520 525

Glu His Gly Ile Glu Ala Thr Val Val Asn Ala Arg Phe Val Lys Pro
530 535 540

Leu Asp Thr Glu Leu Ile Leu Pro Leu Ala Glu Arg Ile Gly Lys Val
545 550 555 560

Val Thr Met Glu Glu Gly Cys Leu Met Gly Gly Phe Gly Ser Ala Val
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Ala Glu Ala Leu Met Asp Asn Asn Val Leu Val Pro Leu Lys Arg Leu
580 585 590

Gly Val Pro Asp Ile Leu Val Asp His Ala Thr Pro Glu Gln Ser Thr
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Val Asp Leu Gly Leu Thr Pro Ala Gln Met Ala Gln Asn Ile Met Ala
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<211> 633

<212> PRT

<213> Bacillus subtilis

<400> 2

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Thr Ser Leu Ser Ala Ser Gly Gly His Ile Gly Pro Asn Leu Gly Val
35 40 45

Val Glu Leu Thr Val Ala Leu His Lys Glu Phe Asn Ser Pro Lys Asp
50 55 60

Lys Phe Leu Trp Asp Val Gly His Gln Ser Tyr Val His Lys Leu Leu
65 70 75 80

Thr Gly Arg Gly Lys Glu Phe Ala Thr Leu Arg Gln Tyr Lys Gly Leu
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Cys Gly Phe Pro Lys Arg Ser Glu Ser Glu His Asp Val Trp Glu Thr
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Gly His Ser Ser Thr Ser Leu Ser Gly Ala Met Gly Met Ala Ala Ala
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Asp	Glu	Lys	Lys	Asp 165	Met	Ile	Val	Ile	Leu 170	Asn	Asp	Asn	Glu	Met 175	Ser
Ile	Ala	Pro	Asn 180	Val	Gly	Ala	Ile	His 185	Ser	Met	Leu	Gly	Arg 190	Leu	Arg
Thr	Ala	Gly 195	Lys	Tyr	Gln	Trp	Val 200	Lys	Asp	Glu	Leu	Glu 205	Tyr	Leu	Phe
Lys 210	Lys	Ile	Pro	Ala	Val	Gly 215	Gly	Lys	Leu	Ala	Ala 220	Thr	Ala	Glu	Arg
Val 225	Lys	Asp	Ser	Leu	Lys 230	Tyr	Met	Leu	Val	Ser 235	Gly	Met	Phe	Phe	Glu 240
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Glu	Leu	Ile	Glu 260	Asn	Leu	Gln	Tyr	Ala 265	Lys	Lys	Thr	Lys	Gly 270	Pro	Val
Leu	Leu	His 275	Val	Ile	Thr	Lys	Lys 280	Gly	Lys	Gly	Tyr	Lys 285	Pro	Ala	Glu
Thr 290	Asp	Thr	Ile	Gly	Thr	Trp 295	His	Gly	Thr	Gly	Pro 300	Tyr	Lys	Ile	Asn
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Ala	Lys	Glu 355	Phe	Pro	Asp	Arg	Met 360	Phe	Asp	Val	Gly	Ile 365	Ala	Glu	Gln
His 370	Ala	Ala	Thr	Met	Ala	Ala 375	Ala	Met	Ala	Met	Gln 380	Gly	Met	Lys	Pro
Phe 385	Leu	Ala	Ile	Tyr	Ser 390	Thr	Phe	Leu	Gln	Arg 395	Ala	Tyr	Asp	Gln	Val 400
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Arg	Ala	Gly	Leu 420	Val	Gly	Ala	Asp	Gly 425	Glu	Thr	His	Gln	Gly 430	Val	Phe
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Lys Asp Glu Asn Glu Gly Gln His Met Val His Thr Ala Leu Ser Tyr
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Asp Glu Gly Pro Ile Ala Met Arg Phe Pro Arg Gly Asn Gly Leu Gly
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Val Lys Met Asp Glu Gln Leu Lys Thr Ile Pro Ile Gly Thr Trp Glu
485 490 495

Val Leu Arg Pro Gly Asn Asp Ala Val Ile Leu Thr Phe Gly Thr Thr
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Ile Glu Met Ala Ile Glu Ala Ala Glu Glu Leu Gln Lys Glu Gly Leu
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Glu Ala Val Leu Glu Gly Gly Phe Gly Ser Ser Ile Leu Glu Phe Ala
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His Asp Gln Gly Glu Tyr His Thr Pro Ile Asp Arg Met Gly Ile Pro
580 585 590

Asp Arg Phe Ile Glu His Gly Ser Val Thr Ala Leu Leu Glu Glu Ile
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Pro Lys Thr His Lys Gly Ile Gly Ser
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<212> PRT

<213> Escherichia coli

<400> 3

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His Phe Ala Ser Gly Leu Gly Thr Val Glu Leu Thr Val Ala Leu His
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Tyr Val Tyr Asn Thr Pro Phe Asp Gln Leu Ile Trp Asp Val Gly His
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Gln Ala Tyr Pro His Lys Ile Leu Thr Gly Arg Arg Asp Lys Ile Gly

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Val	Lys	Lys	Arg	Ser	Arg	Val	Val	Gln	Ala	Ser	Leu	Ser	Glu	Ser	Gly
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Glu Tyr Tyr Thr Gln Arg Pro Pro Thr Pro Ile Leu Asp Thr Val Asn
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 Tyr Pro Ile His Met Lys Asn Leu Ser Leu Lys Glu Leu Lys Gln Leu
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 Ala Asp Glu Leu Arg Ser Asp Thr Ile Phe Asn Val Ser Lys Thr Gly
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 Gly His Leu Gly Ser Ser Leu Gly Val Val Glu Leu Thr Val Ala Leu
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 His Tyr Val Phe Asn Ala Pro Gln Asp Arg Ile Leu Trp Asp Val Gly
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 His Gln Ser Tyr Pro His Lys Ile Leu Thr Gly Arg Arg Asp Lys Met
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